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Abstracts of Principal Articles

The Production of VDF Standard Lathes P. 232

In this article, are described typical operations on some of the principal components for lathes built at the Hamburg works of Heidenreich & Harbeck. The machining of headstocks, gear-boxes and aprons is considered first, and in this connection reference is made to two hydraulically-operated horizontal machines which have been developed specially for this purpose. One of these machines has two, and the other three, spindle heads, and, to facilitate rapid changing, the tungsten carbide tools in the boring bars are pre-set with the aid of special gauges. In addition, tool storage arrangements are such that all the equipment required for a particular set-up is readily accessible. A feature of the 3-way machine is the provision of indexing control drums for the rapid selection of various working cycles. Among other operations considered, may be mentioned finish boring headstocks and tailstocks, honing tailstocks, induction hardening gear teeth, and profile grinding gears. For the latter operation, expanding mandrels of special design are employed, so that run-out is kept to a minimum. Attention is drawn also to the methods used for headstock assembly. (MACHINERY, 92—31/1/58.)

The Kaukauna Triple-control Positioning Equipment for Machine Tools..... P. 246

Equipment which provides for manual, digital, or punched-tape control of a machine such as a floor-type horizontal borer has been introduced. The horizontal position of the column on the bed and the vertical position of the head on the column are controlled by the system with the aid of electronic measuring equipment. With manual control, fast and slow traverses are obtained by push buttons. When a main switch is moved to " dial," the operator can set the required dimensions, as read from the drawing, on series of dials. Alternatively, for fully-automatic positioning, a punched-tape control system can be brought into operation. Movements are measured by means of Inductosyn scales. (MACHINERY, 92—31/1/58.)

Modern Presswork Techniques..... P. 249

In a paper presented at the recent Annual Conference of the Institute of Sheet Metal Engineering, Mr. T. G. Woodward discussed some modern high-production presswork techniques. He described the procedure to be followed in the design of multi-stage tools, and advocated the use of cheap experimental tool units for " proving " the proposed strip layout and method of production. Some interesting tool designs were considered in detail, including those in which curling, cracking and drawing stages are incorporated. The first half of his paper concluded with descriptions of various electro-mechanical and pneumatic arrangements for safeguarding tools. (MACHINERY, 92—31/1/58.)

Machining Operations on Pontiac Stub Axles .....P. 261

In the 1958 Pontiac car, a combined stub axle and support member is employed. After the forgings have been heat-treated, they are centre-drilled and spot-faced, at both the yoke and stem ends. Subsequent operations provide for copy-turning the stem and finish-facing the flange; grinding the bearing and oil-seal contact surfaces; and broaching the ball-stud bosses and qualifying pads. Machining is then completed on two identical Buhr 16-station transfer machines. For comparison, it may be noted that for similar operations on an earlier design of stub axle, 12 separate machines, each with an operator, were required. Reference is made to the work performed at various stations on the transfer machines, and to the arrangements for returning the pallet fixtures to the loading station. Each of these fixtures holds two stub axles, and provision is made for automatic clamping and unclamping. (MACHINERY, 92—31/1/58.)

The Establishment of Dimensional Norms for Die Castings..... P. 267

In this article, the subject of die casting tolerances is examined at length, with particular reference to the standards which have been introduced by the Zinc Alloy Die Casters' Association for the guidance of British designers and buyers. The history of the die casting industry is first touched upon, and the tendency for users of die castings to " over specify " is then discussed. Subsequent sections are concerned with such matters as the function of product standards; factors which affect the dimensional accuracy of die castings; and the A.D.C.I linear tolerances. Next, the new " Engineering Standards for Pressure Die Casting " are considered in some detail, and various suggestions are made. For example, the appropriateness of the term " critical dimensions " is questioned. Notes are also included under the headings: precision obtainable; dimensions across the parting line; dimensions controlled by moving core blocks; draft; flatness; depth and taper of holes; ejector pin marks; machining allowances; and flash removal. (MACHINERY, 92—31/1/58.)

Contributions to MACHINERY

If you know of a more efficient way of designing a tool, gauge, fixture, or mechanism, machining or forming a metal component, heat treating, plating or enamelling, handling parts or material, building up an assembly, utilizing supplies, or laying out or organizing a department or a factory, send it to the Editor. Short comments upon published articles and letters on subjects concerning the metal-working industries are particularly welcome. Payment will be made for exclusive contributions.

IN FORTHCOMING ISSUES

The production of components for Lambretta motor scooters.

Sensitive Movement of Machine Tool Slides

Among the problems with which machine tool designers have long been confronted are those concerned with the movement of slides, tables, columns, and other members, on guiding surfaces. The basic requirements are, of course, straightness of motion, which must be maintained within close limits during long periods of service, and motion that is uniform, even for heavy masses and very slow speeds. Provided that the initial form, accuracy, and finish of the mating surfaces are suitable, the satisfaction of both these requirements demands a reduction of the coefficient of sliding friction to the lowest practicable value. It is particularly desirable, moreover, that the stick-slip phenomenon should be eliminated as far as possible, to enable movement to be imparted reliably in very small increments.

A great deal of research has been devoted to these problems in the past, and valuable improvements have been obtained, for example, from devolopments in methods of finishing surfaces; the hardening of guiding surfaces on castings; application of hardened steel guide strips; use of plastics material for one of the mating surfaces; better provision for lubrication; treatment with low-friction solid lubricants, such as molybdenum disulphide; and careful exclusion of dirt.

With the increasing demands for accuracy and sensitivity, however, such expedients do not always suffice, and much attention has been directed in recent years to what may be termed mechanical solutions. For the purpose of avoiding stick-slip movement, for instance, a so-called woodpecker device has been applied to provide a tapping action. In general, however, the mechanical solutions have depended on a transition from sliding to rolling motion, and various arrangements have been adopted with highly successful results. Attention may be drawn, in this connection, to the use of ball guides of both non-circulating and circulating types; ball bushes which are employed in conjunction with cylindrical guides; and various roller guide systems. For one of the latter systems, the rollers are conveniently assembled in the form of chains, and here again, provision can be made for circulation, if required. These rolling guide arrangements permit much freer and more sensitive movement than was previously obtainable, and it is likely that they will be applied on an increasing scale to certain types of machine tools.

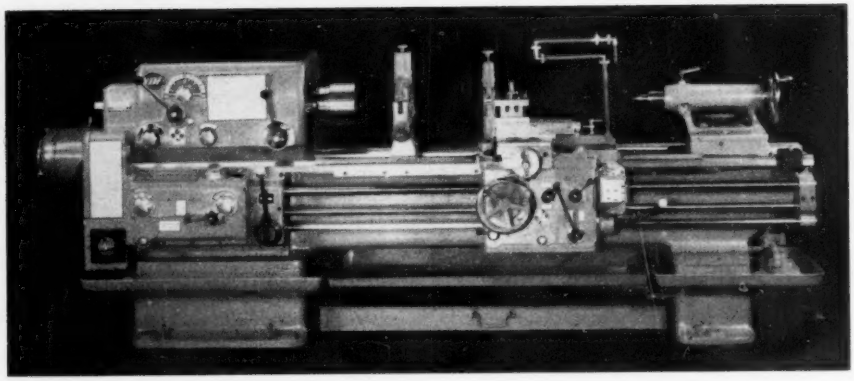
With the advent of fully automatic control systems for machines, fresh standards of mechanical performance have been demanded in order that the potential accuracy of such systems may be realized. Here the previous difficulties have been accentuated by the fact that some of the most promising applications of these systems involve massive machines of large capacity, with which highly sensitive movement and response have not hitherto been commonly associated. In particular, interest is centred, at the moment, in machines designed to provide movement in at least three directions, for the production of large and intricate aircraft components.

In an effort to overcome certain limitations of previously-introduced methods of supporting and guiding large sliding masses, a different approach has been adopted in the design of a recently constructed machine, which, it is understood, has yielded very striking results. It is already well known that heavy weights can be moved very easily when supported by a film of air under pressure, and this principle of air-flotation has been turned to good account in a variety of applications. Thus, by temporarily introducing a cushion of air beneath a heavy jig or table, it may be moved into position or indexed by hand with a mininum of effort.

No doubt air-flotation could also be applied to machine slides where a very sensitive movement was required solely for the purpose of accurate setting. An air film, however, does not provide a sufficiently stable support where machining must be carried out while a slide or column is in motion. On the other hand, it has been found that, with a correctly designed system, the substitution of oil-flotation for air-flotation enables the necessary stability to be achieved while retaining an astonishing sensitivity. With a suitable control system it has, indeed, been found possible to hold a heavy column stationary, for carrying out a machining operation, while it is supported solely on an oil film and not secured by any clamps.

To check the freedom of movement which can be obtained in this manner, various tests have been carried out, and it may be noted that a column weighing several tons, when mounted on its bed but not connected to the traversing drive, was moved by a thread tensioned only by a suspended

(*Continued on page* 285)



The Production of VDF Standard Lathes

Methods Employed at the Works of Heidenreich & Harbeck, Hamburg

The German VDF Group (Vereinigte Drehbank-Fabriken), which was formed as long ago as 1927, consists of the firms of Heidenreich & Harbeck, Hamburg, H. Wohlenberg K.G. Hanover, and Gebr. Boehringer G.m.b.H., Goppingen. Originally, the group included Franz Braun, Zerbst. This company was located in what is now the Eastern Zone of Germany, and it no longer exists. The VDF Group is, at present, one of the largest organizations in Germany engaged in the building of machine tools. An important part of the output comprises centre lathes, of designs which have been the subject of rationalized development by the group over a period of many years. In addition to centre lathes, which are made in sizes up to 80-in. swing over the saddle, the Group builds the well-known Unicop and Hydrokop copying lathes, also turret lathes, deep-hole boring machines, crankshaft lathes, automatic bevel gear generators, planing machines, and machine tools for special purposes.

This article relates to the production of lathes by the firm of Heidenreich & Harbeck, Hamburg, which was established more than 80 years ago. Some 2,600 people now are employed on the manufacture of VDF standard centre lathes in the small and medium sizes, with centre heights from 7 to 10 in., also copying lathes, turret lathes, automatic bevel gear generators, deep-hole boring machines, and, to a smaller extent, certain types of special-purpose machines. At present, the output of lathes is approximately 120 per month, and this figure may include a large proportion of standard centre lathes, with a maximum of about 30 of any particular size.

The works, extensively re-built since the war, and equipped with the most modern machine tools, are laid out to provide for efficient batch production. The company operate their own foundry, which is located some 40 miles from Hamburg, and is able to provide the majority of the castings required.

In order to ensure an adequate supply of skilled labour capable of building high-class machine tools, the company pay very close attention to the training of apprentices, and for many years a comprehensive system has been in operation. Some 320 apprentices, of ages from 14 to 18, are passing through the company's school, where emphasis is placed on adequate training in fitting, machine operating, and other practical skills. All the machine tools in the apprentice school are modern and of high quality, and the work undertaken by apprentices during their final training period includes the complete overhaul of machine tools used in the works. Upon completion of the overhaul, the machine tool in question must conform in every respect to the standards laid down for new machine tools made by the company. By means of an exchange system, apprentices from firms in other European countries, including Great Britain, are able to spend a three-month period in the company's school, and recently, for example, three apprentices from Ruston & Hornsby Ltd., Lincoln, received training there.

A typical example from the VDF range of stan-

dard lathes, the S500, of 10-in. centre height, is shown in the heading illustration. It has 30 spindle speeds, from 9 to 1,800 r.p.m., the drive being taken directly by belt for a range of speeds from 140 to 1,800 r.p.m. A lower range, from 9 to 450 r.p.m., is obtained through a gear train. Attention may also be drawn to the type 18 RO, 7-in. centre lathe, which was shown at the Fifth European Machine Tool Exhibition fitted with a high-speed headstock driven by a pole-changing motor at spindle speeds up to 4,000 r.p.m. This type of headstock can also be fitted on the VDF 21 RO lathe, of 8¼-in. centre height, and to the type S lathes, the latter then having a maximum spindle speed of 5,600 r.p.m.

MACHINING HEADSTOCKS, GEARBOXES AND APRONS

Outstanding among the equipment that has been specially developed for the production of VDF lathes are two hydraulically-operated horizontal machines, one with two, and the other with three, spindle heads. These machines have been designed and built by the company, for carrying out, economically, the boring, drilling, reaming and tapping of a considerable proportion of the holes required in headstocks, gearboxes and aprons for all the sizes of standard centre lathes, also in headstocks for RS 80 and RS 100 turret lathes, made at the Hamburg works.

The 2-way machine, which is employed solely for drilling and boring operations on headstocks, in line with the spindle axis, is seen in Fig. 1 with the fixture open and unloaded, and in Fig. 2, with a casting in position. Preliminary operations on the casting comprise planing and hand-scraping the under-side to provide vee and flat location surfaces, and milling the side, top and end faces on a Köllmann machine.

On the boring machine, Fig. 1, the work is loaded on to the fixture base *A*, up to a stop at the left-hand end, and is located transversely, at each end, by V-tenons, as at *B*, which engage the previously-machined V-grooves on the under-side of the casting. For the set-up shown, the tenons are carried on packing plates, which can be removed to allow headstocks of the same general design, but of greater centre height, to be clamped directly on the fixture base. The casting is gripped at the flanged end by two hydraulically-operated toe clamps *E*, Fig. 2, which turn through 90 deg. to the working position, as they move down. Two swing-type toe clamps, as at *D*, Fig. 1, hold the casting at the opposite end.

The piloted boring bars are guided in the bush block *E*, Fig. 1, on a substantial pivoted arm *F*, which is actuated hydraulically through a rack and pinion. In the working position, it rests on a hydraulically-pivoted support *G*, fitted, at the top, with hardened-steel V-tenons, which engage mating grooved inserts in the arm. The latter is locked to the support by two latches, and the pivoting and locking motions are controlled by a single lever. Automatic lubrication, by means of

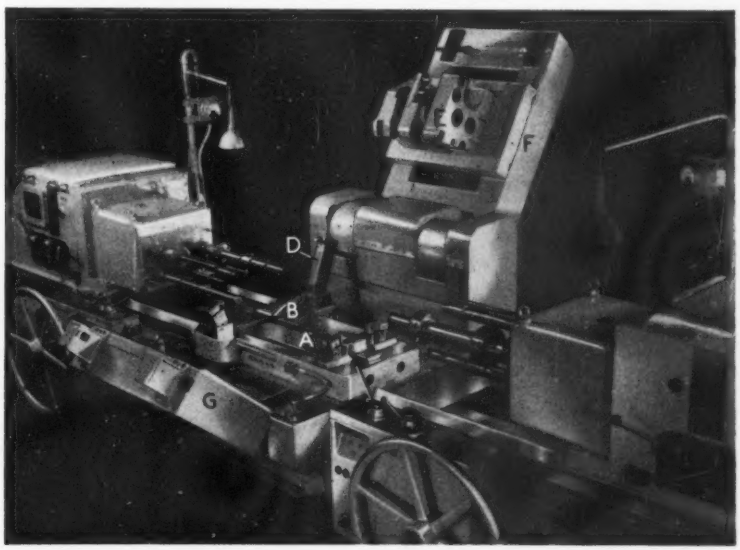


Fig. 1. A View, with the Fixture Open and Unloaded, of the 2-way Hydraulic Machine built by the VDF Company for Drilling and Boring Operations on Headstock Castings

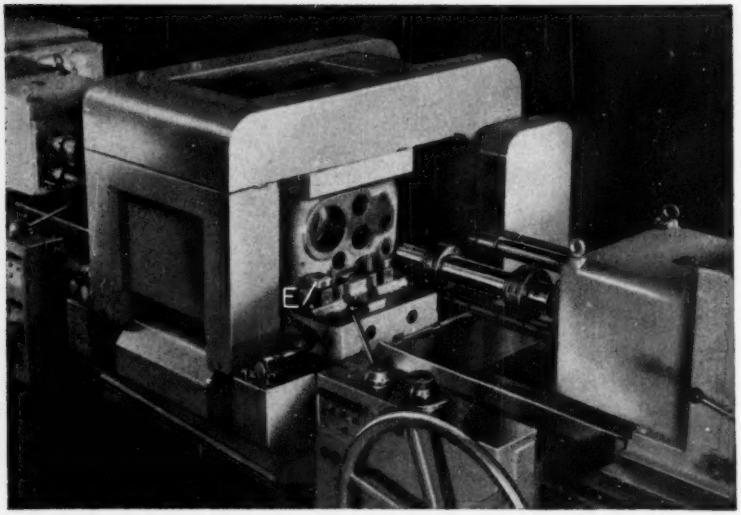


Fig. 2. Close-up View of the Machine Shown in Fig. 1, with a Headstock Casting Clamped in the Fixture

a pump, is provided for the guide bushes. Provision is made for readily replacing the fixture base, the spindle heads, and the guide bush block with others, when different headstocks are to be machined. In all, three main types of headstocks are handled on this machine, each with two different centre heights.

Twenty-four spindle speeds, ranging from 65 to 880 r.p.m., are obtained by sliding gears in each head, which, in conjunction with steplessly-variable hydraulic feed rates, enable the various drilling, boring and facing operations to be efficiently performed. The cycle of rapid approach, feed, and rapid return is automatic, and a feature of special interest is that very accurate depth control is obtained, when machining faces and counterbores, by means of the firm's Unicop electronic-hydraulic stylus units, as employed on VDF copying lathes.

Operations performed on this 2-way machine are carried out in several stages, and for the headstock seen in Fig. 2, for a type E3, 9-in. centre lathe, there are four stages. After the first two stages have been completed at one set-up, the casting is unloaded and the underside is finish planed and scraped to ensure an accurate seating face for the two subsequent stages, at which all the bores except those for the spindle bearings are finished to a tolerance of 0·001 in. Tolerances specified on centre distance range from $-0{\cdot}000$ $+0{\cdot}002$ to $\pm 0{\cdot}004$ in.

To expedite production and ensure full utilization of the machine, the tungsten carbide tools in the boring bars are set to cutting size in the toolroom with the aid of special gauges. The bars, together with all the other cutting tools are stored, ready for immediate use, in vertical pull-out racks as seen in Fig. 3, each rack containing the tools for a particular set-up. Headstock castings are handled in minimum batches of 40, and the time allowed for carrying out the four machining stages on the casting seen in Fig. 2 is 2½ hours. The setting up time is 2 hours, and these times are so calculated as to enable the operator to earn 35 per cent bonus. Reference will be made later to the finishing operation on the main spindle bores, which

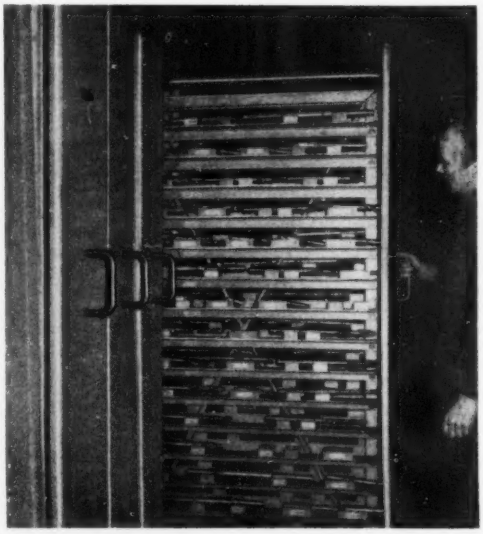


Fig. 3. Vertical, Pull-out Racks are Provided for Holding the Tooling Equipment Used on the VDF Special-purpose Machines

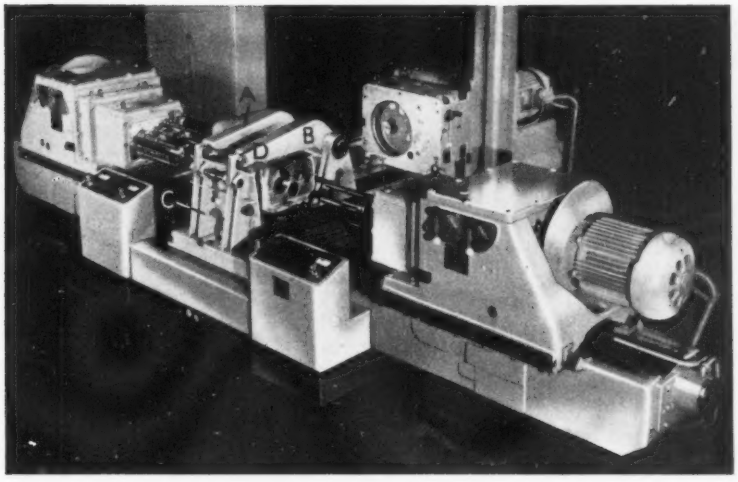


Fig. 4. The VDF 3-way, Hydraulically - operated Machine Set Up for Operations on Headstock Castings

is carried out at a subsequent stage, immediately after the vee and flat ways on the under-side of the casting have been finish scraped.

THREE-WAY SPECIAL-PURPOSE MACHINE

The 3-way machine, in addition to handling three types of gearboxes and aprons, is also employed for carrying out boring operations on headstocks for the types 18 RO and 21 RO centre lathes of 7 in. and 8$\frac{3}{16}$ in. centre height. A general view of the machine, set up for boring headstocks, is shown in Fig. 4, and a rear view, as arranged for performing operations on gearboxes, in Fig. 5.

Only the right- and left-hand heads are used for operations on headstocks, and the design of the fixture is generally similar to that seen in Fig. 1, on the 2-way machine. The automatically-lubricated guide bushes for the boring bars are carried on two hydraulically pivoted, welded-steel arms *A* and *B*, which, in the working position, are clamped to hardened and ground bearing plates on top of the fixed, welded-steel vertical member *C*. Locking is effected by means of two pivoted hook clamps, as at *D*, which are operated by a single hand lever. Location for the work is taken from the vee and flat ways on the under-side of the casting, and the latter is secured by two toe clamps at the front, and one in the centre at the rear, which bears on the top cover face. In this instance, the clamps are tightened by hand. Packing plates are secured to the fixture base when handling the headstocks of smaller centre height.

For each head, 32 spindle speeds, ranging from 27·6 to as high as 853 r.p.m., are provided, and

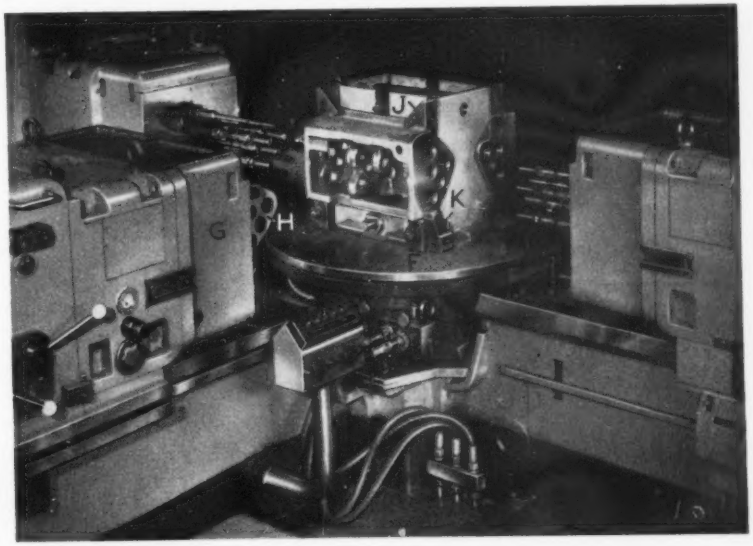


Fig. 5. View, from the Rear, of the 3-way Machine Arranged for Handling Gearboxes

the hydraulic feed rates are steplessly variable. As on the 2-way machine, accurate depth control is obtained through the medium of Unicop electronic-hydraulic stylus units. Because of the appreciable number of different set-ups that is involved in carrying out the various stages of machining on headstocks, aprons and gearboxes, special attention has been given in the design of the machine to reducing, to a minimum, the time required for setting the various automatic cycles for the spindle head movements. Associated with each head there is an indexing drum, mounted on the side of the bed as seen at *D* in Fig. 6, which is provided with 20 longitudinal dovetail grooves, wherein are fastened, in pre-set positions, the dogs *E*, for operating the cycle control switches. In each groove, at the left-hand end, is fastened an indicator plate, whereon is stamped a reference to the component and the particular operation for which the dogs are set, so that it is only necessary to rotate the drum by hand, as shown, to obtain the cycle required. Safety switches at the left-hand side ensure that the machine cannot be started if the drum is not properly indexed.

When aprons and gearboxes are to be machined, the entire fixture seen in Fig. 4 is removed from the main base plate at the centre of the bed, and is replaced by a heavy-duty rotary table, as shown at *F* in the rear view of the machine in Fig. 5. The table can be indexed through 180 deg. by a push-button controlled electric motor, and is arranged to carry 2-station fixtures for the different types of aprons and gearboxes, so that loading and unloading can be carried out while a casting is being machined. In Fig. 5, the machine is set-up for performing drilling, boring and facing operations on gearboxes. The detachable multi-spindle unit *G*, at the rear, in addition to carrying cutting tools, is fitted with a pump-lubricated guide bush block *H*, for the piloted boring bars in the right- and left-hand heads. Upon completion of its forward traverse, the rear head dwells against a dead stop while the right- and left-hand boring operations are performed.

The fixture, of relatively simple design, is of welded steel construction, and is fitted with four dog clamps as at *J*, for holding the casting against the vertical face. Location endwise is provided by a stop *K*, against which the casting is held by a dog clamp at the opposite end. Datum blocks on the table ensure that the various fixtures are accurately located in relation to the spindle heads.

Fig. 7 shows the machine set-up for carrying out one of the series of operations on aprons for type S centre lathes of 9-in. and 10-in. centre height, the rear spindle head, in this instance, being employed solely for performing drilling operations. The fixture is of welded-steel construction, and the swing-over clamps, which engage the top of the casting, are tightened by hand. On both the 2-way and 3-way machines, it may be noted, high-speed steel twist drills, with tungsten-carbide inserts brazed into cross slots at the points, are employed, which are found to have extended life when drilling cast iron. On this apron casting, the operations are carried out in three successive stages, and the time allowed for machining each casting is 1¾ hours.

Aprons and gearboxes are usually handled in minimum batches of 80. Vertical racks of the type shown in Fig. 3 are provided for storing the pre-set tools, for each stage of machining. It is stated that some 29 standard-type machines, together with a considerable amount of tooling, would be required to perform the same work as the two special-purpose machines described.

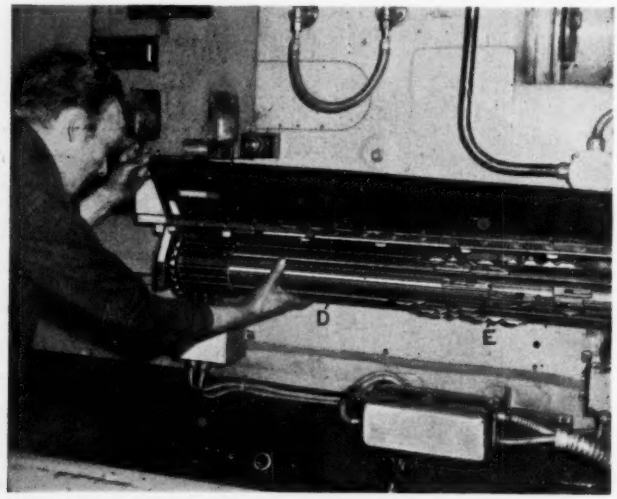


Fig. 6. The Indexing Control Drum, with Pre-set Dogs, which Enables the Required Cycle to be Rapidly Selected on the 3-way Machine

Fig. 7. The 3-way Machine Set Up for Carrying Out Operations on Lathe Aprons

bed. Location for the work is taken from the scraped vee and flat ways on the under-side, which rest on packing blocks *F* of a thickness to suit the centre height of the headstock. These blocks, in turn, are located by vee and flat ways on top of the saddle. The work is clamped from below, at each end, by means of hydraulically - operated pull bars, which engage bayonet sockets in two blocks attached to the under-side of the casting before it is loaded. A pull-down cylinder also is provided at the centre, which is employed for clamping tailstocks, mounted on their bases, as seen in Fig. 9. Here, the head of the ram in the cylinder *G* engages a cross pin *L*, inserted in the casting.

FINISH BORING HEADSTOCKS AND TAILSTOCKS

For the important operation of finishing the headstock main-bearing bores, also for finish-boring tailstocks, the company employ the horizontal machine shown in Fig. 8, which has been in use for a number of years, and was specially built for the purpose by the German firm Vomag (now Ludwigsburger G.m.b.H.). In the illustration, the machine is seen set-up for boring a headstock for a type 18 RO lathe of 7 in. centre height.

The casting *A*, together with the adjustable, rotating - bush, steadies *B* and *C* for the boring bar *D*, are carried on a saddle *E*, which is traversed hydraulically along the

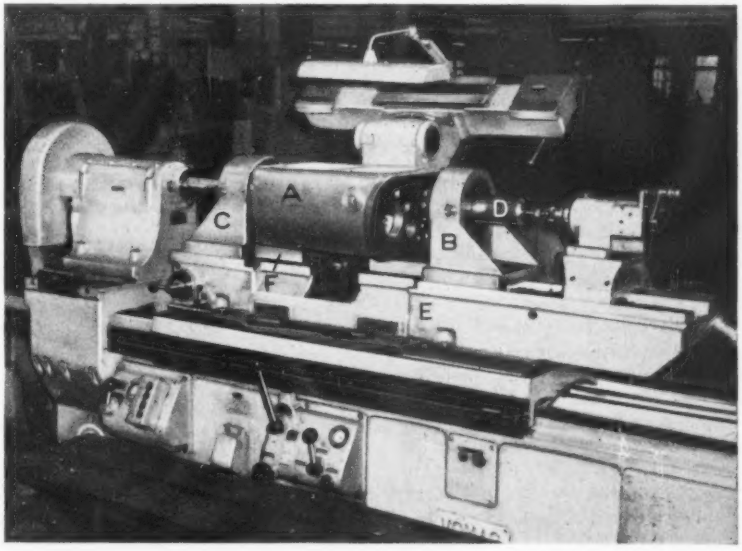


Fig. 8. Finish-boring the Main Spindle Bores in a Headstock Casting on a Special-purpose Hydraulically - operated Machine

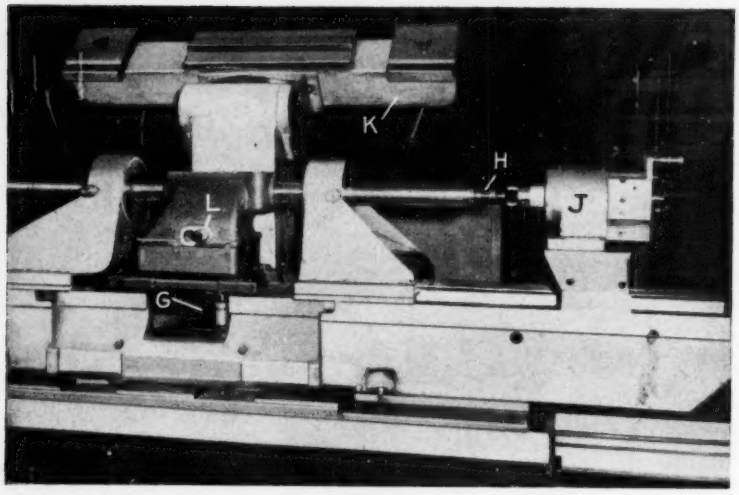


Fig. 9. Set Up for Fine-boring a Tailstock on the Machine Seen in Fig. 8

Steplessly-variable speeds are available for the boring headstock, and the spindle, which runs in adjustable plain bearings, is provided with a universal coupling for attachment of the boring bar. To ensure that abutment faces in the headstock casting are machined accurately square with the bores, provision is made for performing facing operations at the same set-up, by means of out-feeding tools. These tools are actuated through the medium of a centre rod *H*, Fig. 9, in the bar, which is pushed inwards, to the left, by means of a hydraulic ram in the head *J* on the saddle, when the latter has completed its traverse to the left, and is held hydraulically against a stop. The amount of the out-feeding movement is determined by adjustable stop nuts on the centre rod, and positive return is ensured by the action of two claws on the ram head, which pivot into engagement with a shoulder on the end of the rod.

Approximately 0·040 in. on diameter is removed at the finish-boring operation, and a tolerance of 0·0005 in. is maintained. It may be noted that it is practice to locate the tailstock bore at a centre height approximately 0·003 in. greater than that of the headstock, to compensate for the heat expansion which occurs in the latter when the lathe is running.

When headstocks for 9-in. and 10-in. centre lathes, types E3, V3, S450, and S500, are being bored, a centre support bearing for the boring bar is provided, which is carried on an overhead, hydraulically-pivoted, arm *K*, Fig 9, mounted at the rear of the saddle. The support bearing is located, as required, and clamped to the machined centre face, and, in the working position, the arm is clamped at the front on a pillar casting, not shown, which is bolted to machined faces provided on the saddle. Adequate illumination, without undue heat, is afforded by a fluorescent lighting fitting.

HONING OPERATIONS ON TAILSTOCKS

Particular importance is attached to the fit of the barrel in the tailstock, and for this reason the tailstock bore is finished by honing on a Gehring

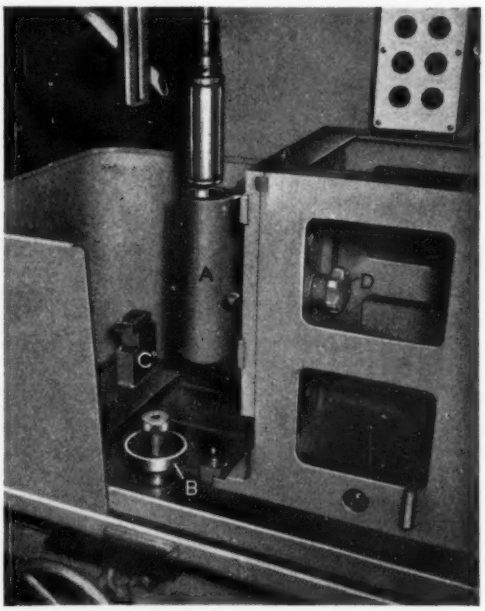


Fig. 10. Finish Honing a Tailstock Bore on a Gehring Vertical Machine Equipped with a Double-sided Fixture to Take Two Sizes of Tailstocks

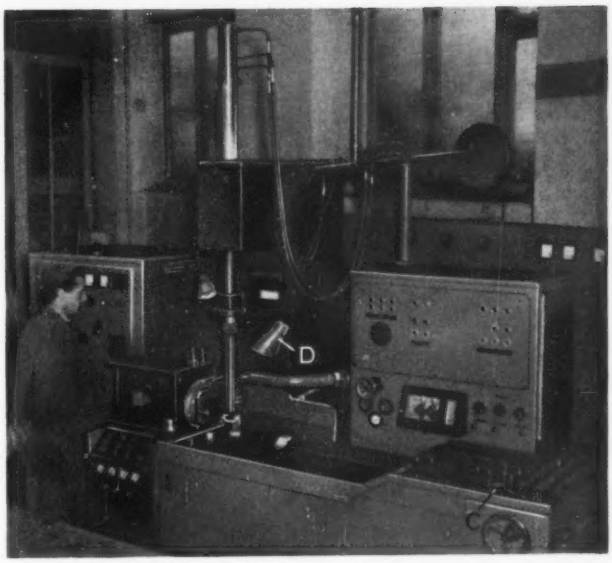


Fig. 11. High-frequency Induction Heating Equipment Developed and Built by the VDF Company for Hardening Gear Teeth

vertical machine, set-up as shown in Fig. 10. The amount removed by honing is approximately 0·002 in. on diameter, and a tolerance of 0·002 mm. (0·00008 in.) is maintained.

The fixture is double-sided, and arranged to handle tailstocks of 65 mm. (2·559 in.) and 90 mm. (3·543 in.) bore, for the various sizes of VDF standard lathes. For honing, the tailstock casting *A* is removed from its base, and is located directly on the fixture, by means of the transverse tenon grooves on the under-side. The crosswise position is established with the aid of a flanged, loose plug *B*, which is inserted in the lower end of the bore. A setting block *C*, mounted on a baseplate, then is moved to the right, and the tailstock is adjusted to bring the flange of the plug into contact with the datum face of the block. The work is clamped by means of a cross pin, and an eyebolt which is tightened by the hand nut *D*. A mixture of 80 per cent paraffin and 20 per cent Vacuum Sultran D oil is employed as a coolant, and the time required for honing a tailstock bore is about 17 min. A Solex air plug gauge is provided for checking purposes.

In connection with honing operations, reference may also be made to equipment, which the company built themselves some years ago, for honing the bores of carriage traversing cylinders for VDF Unicop copying lathes. This equipment was required at a time when a suitable honing machine was difficult to obtain, and the problem was overcome in a relatively simple manner by using, as the basis of the machine, a VDF standard lathe bed, mounted vertically. Hydraulic stroke mechanism, with counterbalance weights, was built for the honing spindle, and a hydraulic motor fitted with a 3-jaw chuck was provided at the lower end of the bed for gripping the work and rotating it at a speed of 30 r.p.m. The workpiece, at the upper end, was supported in a standard 3-point lathe steady. This simple machine is still performing good service on the honing of Unicop cylinders of 80, 90, 100, and 120 mm. bore (3·15 in. to 4·72 in.), up to 1,300 mm. (51 in. long), and surface finishes of 0·20 μ (total depth) are being obtained. Approximately 0·05 mm. (0·002 in.) in diameter is removed from the bore, using 180-200 grit stones for roughing and 320-400 grit stones for finishing. Cut is applied by hand expansion of the hone-head.

INDUCTION HARDENING GEAR TEETH

In connection with profile-ground gears, which are employed extensively in VDF lathes, the company has carried out successful development work on the hardening of teeth by the high-frequency induction method, and they have designed and built the unit shown in Fig 11, which is now in operation on a production basis. This equipment is rated at 100 kW., and is capable of handling gears up to 11 in. diameter.

Referring to the close-up view in Fig. 12, the workpiece is held by the bore on a hydraulically-operated expanding mandrel, carried on the lower end of a vertical spindle *A*, the latter being seen in the working position, with the gear to be hardened located in the water-cooled inductor *B*. During the hardening cycle, the spindle and work rotate to ensure uniform heating of the gear teeth. The spindle forms part of a hydraulic ram and cylinder assembly, and when the heating stage has been completed, as determined by an electric timer, the spindle stops rotating and moves downwards to immerse the gear in the oil quenching tank beneath. The work is then released from the mandrel and falls on to an inclined, roller-chain

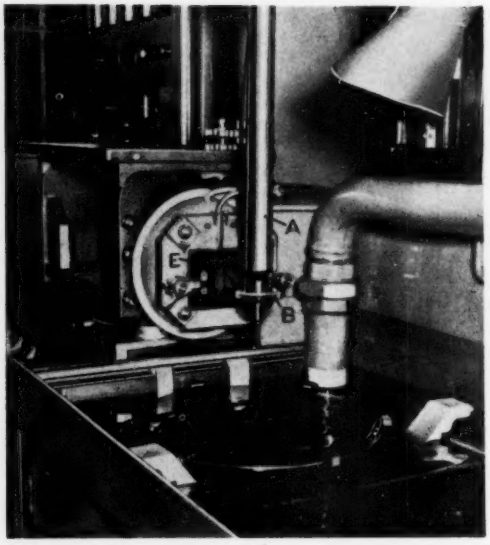


Fig. 12. Close-up View Showing the Work Mandrel and Inductor on the High-frequency Hardening Equipment for Gear Teeth

conveyor, fitted with cross bars, which delivers it on to a draining tray *C*, Fig. 11, at the right-hand end of the tank. A circulating pump is incorporated to maintain the quenching oil at a uniform temperature.

As soon as the workpiece has been released, the spindle moves upwards, clear of the inductor, to enable a fresh gear to be loaded. Expansion of the mandrel is controlled by a push button, and, when another button is pressed, the work moves down into the inductor and starts to rotate, and the high-frequency current is switched on. A motor-driven exhaust fan, connected to a cowl at *D*, removes any fumes produced during heating and quenching.

The operating frequency of the generator is 10,000 cycles per sec., and the gear teeth are through-hardened to a depth of about 0·080 in. below the root. As an example of the production obtainable, it may be noted that a 71-mm. (2¾-in.) diameter gear of 2·75 module (approximately 9 D.P.), and 15-mm. (0·59-in.) face width can be hardened in 30 sec. The speed of rotation of the work spindle is steplessly variable, and for the gear mentioned above, it is 130 r.p.m. Referring to Fig. 12, the inductor coil *B* is mounted on a base plate *E*, which is held in position by quick-acting clamps, and the time required for changing over from one type of gear to another is only about 10 min. A washing unit, supplied by the German firm Paul Kienzle, Pforzheim, is provided adjacent to the high-frequency equipment, for cleaning the hardened gears, the solution employed also imparting some degree of rust protection. At present, gears are being hardened to a minimum of 52 Rockwell C, but investigation is in progress with a view to the adoption of a steel which could be hardened to 60 Rockwell C by this process. Work is also being carried out for the purpose of improving the high-frequency induction heating unit.

PROFILE GRINDING GEARS

For profile grinding operations on gear teeth, three Maag machines and a Reishauer machine, capable of handling both spur and helical gears,

Fig. 13. Maag Gear Grinders Installed in the VDF Hamburg Works

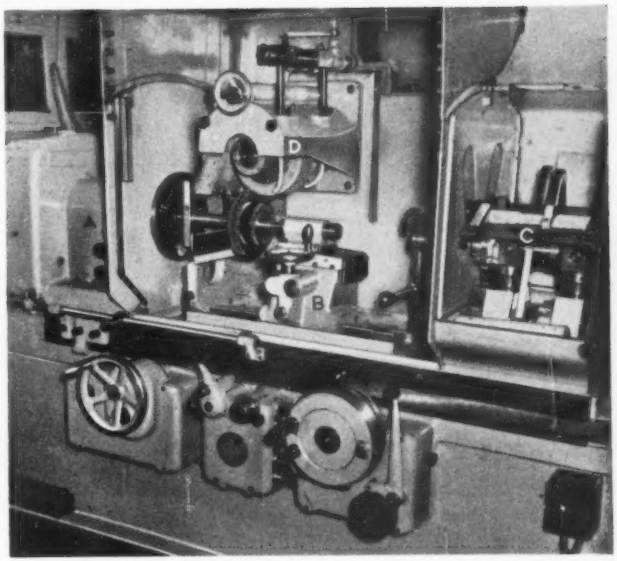


Fig. 14. One of the Schaudt Formed-wheel Grinders Employed for Finishing Spur Gears

are installed. In addition, there are five Schaudt grinders, for spur gears only, and a Reishauer grinder for finishing worms. Certain gears are finished by shaving, for which purpose two machines built by Carl Hurth are used, and where tooth rounding and chamfering are required, the operations are performed on machines supplied by the German firm Uhlig.

The Maag machines in the gear grinding section are seen in Fig. 13. These machines, as is well known, are of the generating type and employ two saucer-type wheels, one for each tooth flank. The wheels have straight faces, and generate the involute profile in the manner of a meshing rack, as the work is traversed, and simultaneously oscillated by an arrangement of steel tapes on a master base circle disc. The Reishauer machine, on the other hand, is equipped with a worm-type grinding wheel provided with rack-form grooves which generate the tooth shape as the work rotates continuously.

On the Schaudt grinder, the wheels are profiled, two wheels being mounted on a common horizontal spindle. One wheel grinds the flank of one tooth, while the other wheel grinds the opposite flank of another tooth, spaced at several pitches from the first. This method of using two spaced wheels has been established for a number of years, and enables the wheel profile to be located on the periphery rather than the side, so that an efficient cutting action is obtained. Two sizes of machine are made, known as the types ZRA 11/250 and ZRA 11/450, and a view of the larger machine—type ZRA 11/450—with guards raised, is shown in Fig. 14. It has a capacity for spur gears from 5 to 17¾ in. base circle diameter, with teeth from about 12 to 2½ D.P. The smaller machine is of generally similar construction and will grind gears of 2 to 10 in. base circle diameter, and 25 to 4¼ D.P. Gears up to 6¾ in. face width can be ground on both machines, and wheels of 10 in. diameter are employed. A maximum distance of 15¾ in. is available between centres.

Hydraulic traverse, at steplessly-variable rates from 4 to 19½ ft. per min., is provided for the table, which carries the workhead *A*, the tailstock *B*, and, at the right-hand end, a diamond dressing unit *C* for the two grinding wheels. The work is indexed automatically from tooth to tooth, after each reciprocation of the table, and, when it has made one revolution, an increment of automatic down feed, variable from 0·0004 to 0·002 in., is applied to the wheel-head *D*. When the required size is reached, the machine stops automatically.

A close-up view of the dressing unit, which is housed within protective covers, is given in Fig. 15. There are two diamonds, one for each wheel, and they are mounted in holders carried on the members *E* and *F*, which project from the casing. Movement of the diamonds through the required involute path, according to the diametral pitch and number of teeth in the gear, is effected directly by an arrangement of steel tapes *G* which are unwound from master base circle drums at *H*, the axes of the drums being located exactly in line with that of the workhead spindle. The truing movement is imparted by a hand lever, at the right-hand side of the attachment.

A separate diamond, carried in a pivoted holder *J*, is provided for dressing the periphery of the wheels. Setting of the diamonds to the correct positions in their holders is carried out—away from the machine—with the aid of a special fixture which incorporates micrometer-adjustable slides and a 30 × Leitz microscope. Positive stops, which are provided on the fixture, correspond with stop faces on the attachment, so that when the

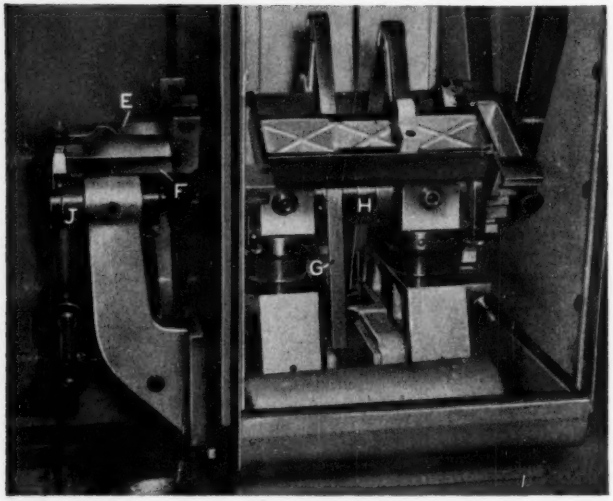


Fig. 15. Close-up View of the Diamond Dressing Attachment on the Schaudt Machine

diamonds have been set, the holders can be clamped directly in their working positions.

A wheel speed of approximately 4,000 ft. per min. is employed, and it is the usual practice to dress the wheels twice during the rough grinding stage, and twice during finish grinding. As an example of the production obtained, approximately one hour is required to grind two 8-in. diameter gears of 0·70-in. face width, mounted back-to-back on a mandrel. A high standard of accuracy is specified for ground gears, and, in this connection, it may be noted that extensive use is made of precision expanding mandrels supplied by the German firm Stieber Rollkupplung KG., Munich, both on the grinding machines and for inspection purposes. The gripping member of the Stieber mandrel is a hardened and ground sleeve which has a slightly tapered bore and is slit to form, in effect, a coarse pitch, close coiled spring. This sleeve is expanded, to grip the work, as it is moved axially over a mating tapered body member, by means of a nut. The running accuracy of the clamped workpiece is stated to be within 0·0001 in.

The company are also using, with good results, precision expanding mandrels of the Spieth patented design which are made by the German firm Moschkau & Glimpel, Lauf-Pegnitz, Bayern, and are sold in this country by B.P.S. Machinery & Spares Co., Ltd., 245 Knightsbridge, London, S.W.7. In addition to mandrels for gripping workpieces by the bore, chucks embodying the same principle are available, for holding parts by the outside diameter. The mandrels are designed for use with workpieces which have been finished in the bore to specified tolerances, and it is stated that under these conditions the accuracy for runout is within 0·00008 in.

Referring to the drawing, Fig. 16, the mandrel in its basic form consists of a hardened and ground steel body *A*, provided with a threaded end and a clamping nut *B*, which exerts axial pressure on the specially-designed, hardened and ground sleeve *C*. The latter is a close sliding fit on the mandrel, and is provided with internal and external annular grooves, of the tapered form shown, which permit uniform elastic deformation to take place radially in all directions, so that the sleeve is caused to grip both the mandrel body and the associated workpiece.

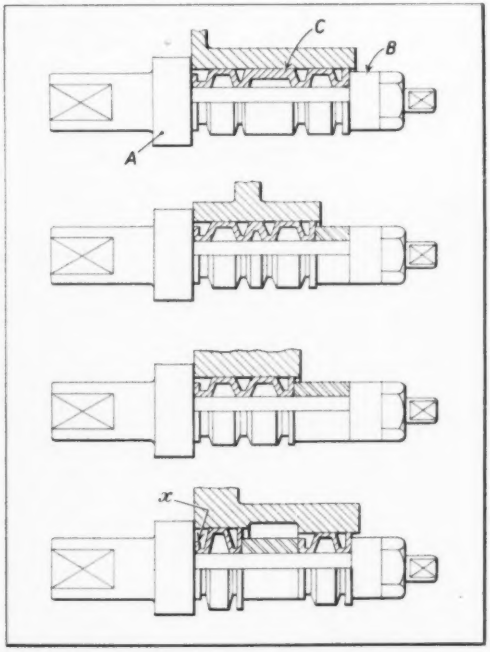


Fig. 16. Components of the Expanding Mandrels Made by Moschkau & Glimpel

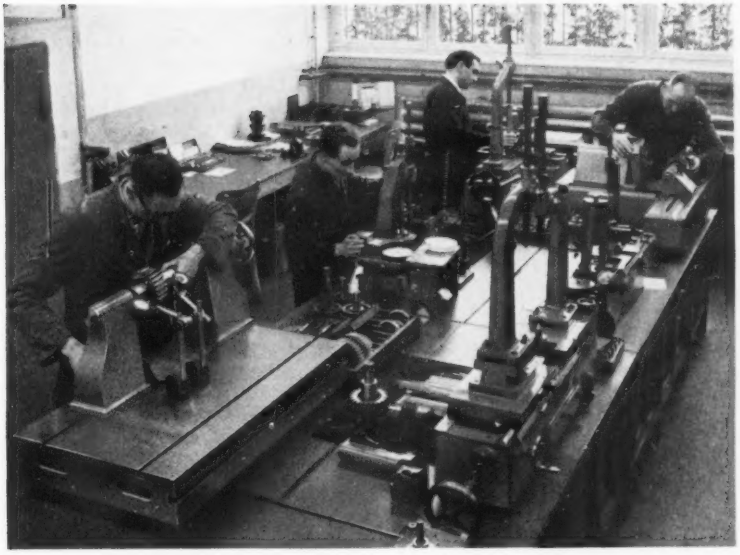


Fig. 17. A View of the Inspection Department for Gears at the VDF Works. Chart Records are Taken of all Ground Gears

Sleeves are available in a range of standard sizes to take workpieces from 14 to 100 mm. ($\frac{9}{16}$ in. to 4 in.) diameter, and the associated mandrel diameters range from 6 to 55 mm. ($\frac{5}{16}$ to 2·16 in.). The fit required for a workpiece on a standard clamping sleeve corresponds approximately to BS.1916D/1957, Class H7. Three types of sleeves are made, with the groove arrangements indicated in the drawing, which cover lengths from 10 to 144 mm. (0·4 to 5·67 in.), the shortest sleeve being also available with a small-diameter flange, as at *x*, at each side. Each mandrel in the range will accommodate clamping sleeves of several outside diameters, and by the use of distance sleeves, which also are available, longer workpieces can be gripped. A similar arrangement can be employed for parts with interrupted or stepped bores. Mandrel and chuck assemblies, specially designed to meet requirements not covered by the standard range, can be supplied, also threaded sleeves for gripping workpieces by a thread, and profiled sleeves for locating components from gear teeth, splines or serrations.

All gears are checked, as soon as they have been ground, in an inspection room which is conveniently located adjacent to the grinding section, so that the operators can see the results of the tests as an aid to machine setting. A view of the inspection room is given in Fig. 17, the equipment

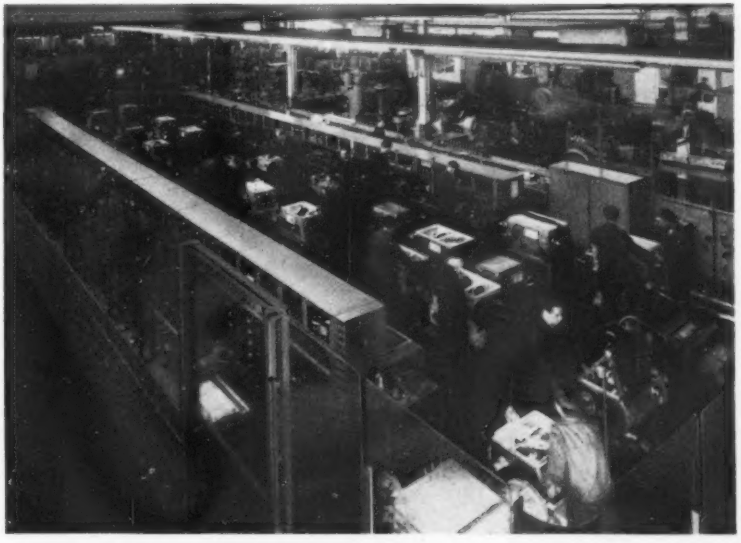


Fig. 18. A General View of the Assembly Section for Lathe Headstocks

Fig. 19. The Arrangement of the Component Store Racks in the Assembly Section for Headstocks

installed including the latest types of pitch, lead, and involute measuring instruments by Carl Mahr and Zeiss. Two chart records are taken on each gear, one for concentricity and the other for involute form over several teeth, the accuracy maintained, it is stated, being within 0·0008 in.

HEADSTOCK ASSEMBLY OPERATIONS

The assembly of headstocks, gearboxes, and aprons is carried out in self-contained sections on a flow system, and, in this connection, attention may be drawn, first, to the efficient arrangements for handling and storing the smaller components, particularly those which are precision machined all over, such as gears and shafts. For these parts, specially-designed wooden trays and holders are provided, which, in turn, are placed in single or multiple tiers, as convenient, in strong metal boxes. The latter, also of special design, can be stacked and transported conveniently from the machine shops by fork truck. In the main finished-parts stores, the boxes are held in slide-in metal racks.

A general view, from the finishing end, of the assembly section concerned with headstocks is given in Fig. 18. There are two assembly tracks, along which the work moves, from stage to stage, on wheeled trolleys, and the headstock castings are carried on fixtures of welded steel construction, which can be swivelled through 360 deg., to facilitate the various assembly operations. Adjacent to each assembly line there is a combined work bench and rack to accommodate the standard boxes of components, which are issued from the stores in the required batches.

Sub-assembly benches, with racks beneath, are provided alongside the glass partitions which enclose the assembly section. The completed sub-assemblies from these latter benches are placed on the main assembly line benches immediately behind, as seen in Fig. 19, which also shows the convenient method of locating a white-spirit cleaning unit A, at one of the slide-in positions of the storage rack. Assembled headstocks are removed from the trolleys at the ends of the lines and loaded on to test stands, seen on the right in Fig. 18, where they are inspected and run-in under power.

The spindles and other shafts in the headstocks of VDF lathes, it may be noted, are checked for dynamic balance after the gears, bearing races, and other rotating components have been assembled, and for this purpose, a Trebel electronic balancing machine is installed. In Fig. 20 this machine is seen set-up for balancing a headstock spindle, the drive being taken from an adapter located in the nose taper. Correction is made for any unbalance

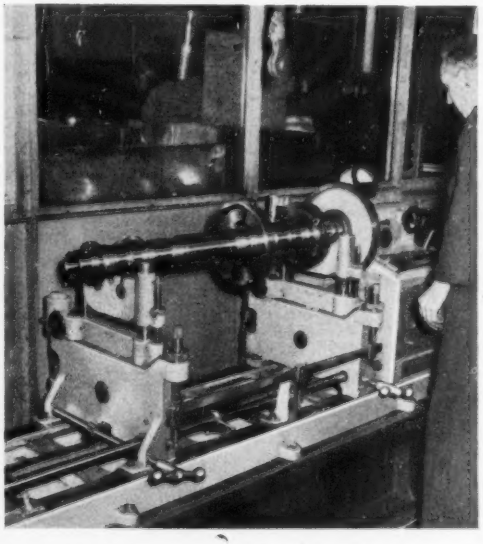


Fig. 20. Balancing a Headstock Spindle Assembly on a Trebel Machine

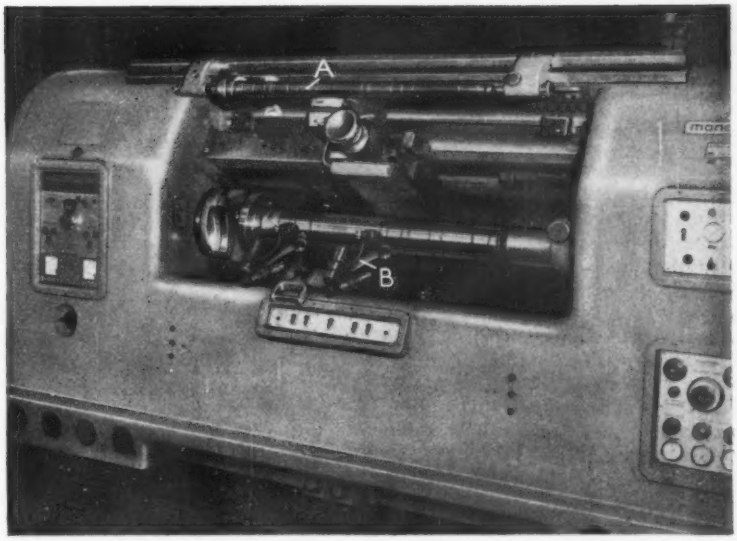


Fig. 21. V.D.F. Monocop Lathe Employed for Turning Spindles

by drilling the flange of the main gear, and, if necessary, the face of the sleeve at the rear end of the spindle.

In connection with the production of spindles, reference may be made to the use of a V.D.F. Monocop hydraulic copying lathe, as shown in Fig. 21, for the rough turning operations. A feature of this heavy-duty production lathe is that the main bed is arranged overhead, and the in-feed tools for turning shoulders and undercuts are adjustably mounted on a substantial, pivoted member, which is moved upwards hydraulically from beneath. A small-diameter round master, seen at *A*, is employed, and the workpiece —in this instance a spindle for a type RS 100 turret lathe—is gripped by the flange periphery in a 3-jaw hydraulic chuck. To facilitate loading and unloading the fairly heavy workpieces, a pivoted arm is provided at the front of the machine which is moved by hand and is fitted with two swing-over brackets *B*, each carrying two pairs of adjustable support bars. One pair of supports on each bracket, for use when loading, is set so that the rough workpiece is brought into line with the lathe axis, and the other pair, used for unloading, is set to support the finish-turned piece. The threads on spindles are ground on a large-capacity Lindner machine, and for boring the central holes, an existing machine is shortly to be replaced by the recently-introduced V.D.F. type B3 high-speed deep-hole boring machine, which was described in MACHINERY 91/704-20/9/57, in connection with the firm's exhibits at the recent Hanover exhibition. This machine will utilize the full capacity of tungsten carbide tools, and is arranged so that the operation can be carried out with the workpiece either stationary or rotating.

V.D.F. lathes are sold in this country by Sykes Machine Tool Co., Ltd., The Hythe, Staines, Middlesex. Other production methods contributing to the high precision of V.D.F. lathes will be described in a later issue of MACHINERY.

Honing the Bores of Grinding Wheels

A type 737 Hydrohoner honing machine, built by the Micromatic Hone Corporation, Detroit 38, Mich., U.S.A., is now being employed by one of the largest manufacturers of abrasive wheels in the United States, for honing the bores of resinoid-bonded snagging wheels. This method of finishing the holes has resulted in a 50-per cent reduction in hole-processing costs, and wheel performance has been improved.

Previously, wheels were ground in the bore after they had been fired, and the side faces had been dressed. For the grinding operation, the wheel was mounted vertically, and clamped on the periphery. The operation involved heavy manual lifting, and frequent gauging of the hole.

Wheels are now transferred directly from the side-facing machine to the Microhoning machine, and located in the horizontal position by means of a retractable plug. From 0·030 to 0·070 in. of material is removed from the bore in approximately 1 min., and a tolerance of less than 0·003 in. (approximately half of the original tolerance) is maintained automatically, without manual gauging. One Microhoning machine has an output that is equal to two grinding machines, and from 400 to 500 wheels are finished with one set of honing sticks. The sizes of the holes that are honed range from 6 to 12 in. diameter.

K

The Kaukauna Triple-control Positioning Equipment for Machine Tools

Equipment which provides for the manual, digital, or punched-type control of a machine has been developed by the Kaukauna Machine and Foundry Division of the Giddings and Lewis Machine Tool Co., Ltd., Kaukauna, Wisconsin, U.S.A. At a recent demonstration, in the Kaukauna Division Plant, this equipment was shown applied to a standard Giddings & Lewis, 5-in. spindle floor-type horizontal boring, milling and drilling machine, as illustrated in the accompanying Fig. 1.

The system controls the horizontal positioning of the column along the main bed, and the vertical positioning of the boring head on the column ways, and includes electronic measuring equipment for both these movements. A panel mounted on the front of the boring head carries all the controls necessary for each of the methods available, and includes a rotary switch for the selection of the required system.

STANDARD MANUAL ELECTRIC CONTROL

Under the manual control system, individual push-buttons are used for traversing the boring head and column. Each button has a dual purpose in that, when the button is depressed for its full stroke, a rapid traverse rate of 100 in. per min. is engaged. If the button is depressed for only half its available stroke, however, a slower traverse of 4 in. per min., for positioning, is obtained. The spindle can be positioned in this manner to an accuracy of 0·001 in.

As can be seen in the close-up view of the boring head, shown in Fig. 2, spindle speeds and feed rates are selected by dials, as are the vertical and horizontal feed rates for milling, and are engaged by pressing the appropriate buttons. All gear shifting is carried out automatically, by electro-hydraulic means, and the coolant-supply and clamping of the head and column are also push-button or rotary-switch controlled.

DIGITAL DIAL CONTROL

When the main rotary switch on the control panel is set to "dial," the machine is ready for operation under the digital control system. The operator can then set, on a series of dials, dimensions taken directly from a conventional working drawing of the part to be machined. In Fig. 2, two rows of flute knobs can be seen, on the desk-type portion of the control panel. The upper bank of six knobs is used for setting dimensions relating to the positioning of the boring head, and the lower bank controls the positioning of the column. Each knob is turned until the required digit appears in the opening *A*, and when the complete dimension has been built-up in this way the read-in button in the bottom right-hand corner of the control panel is depressed, and the information is transferred into the electronic control circuit. At the same time, the selected dimensions appear in the illuminated windows *B*, over the setting dials, thus providing an additional visual check that the

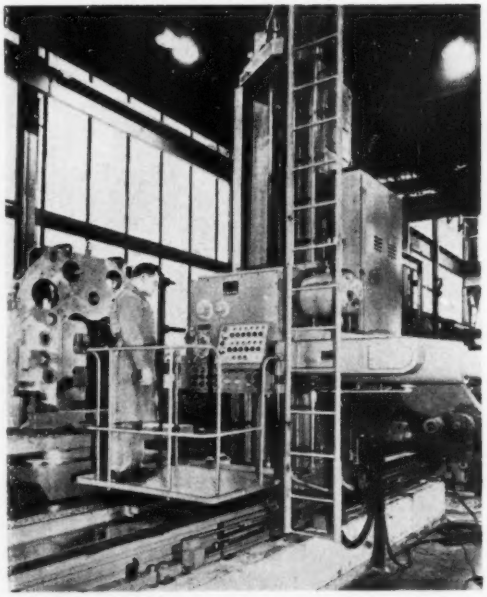


Fig. 1. Giddings & Lewis 5-in. Spindle Horizontal Boring, Milling, and Drilling Machine, Fitted with the Kaukauna Triple-control Positioning Equipment

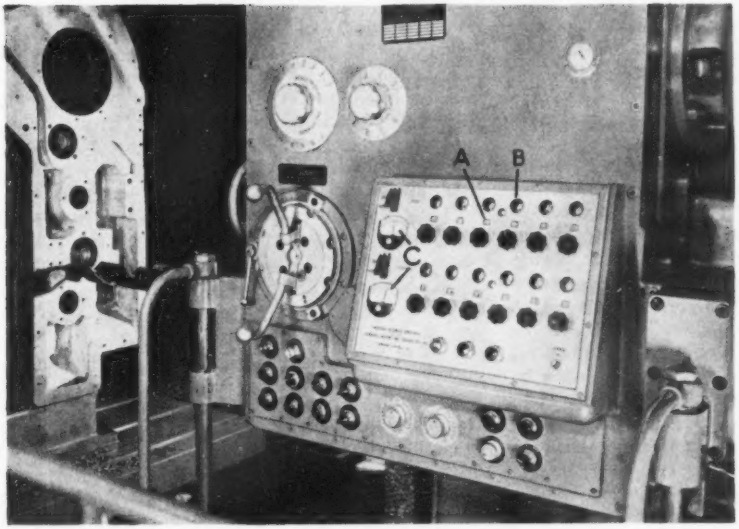


Fig. 2. Close-up View of the Control Panel for the Kaukauna Positioning Equipment, Fitted to the Boring Head of a Giddings & Lewis Horizontal Borer

dimensions have been transferred correctly. On depression of the automatic traverse button, the machine spindle will follow the shortest path to the selected position. As this position is reached, the electronic verniers, shown at *C* in Fig. 2, indicate the degree of accuracy which has been achieved, each vernier being graduated in divisions of 0·0001 in.

While machining is taking place, the ordinates for the next hole can be set on the dials, and by pressing the read-in button the electronic circuit is set-up in readiness for positioning the machine to the next location. Spindle speeds, and all feed rates, are selected by the means employed when the machine is under manual control.

PUNCHED-TAPE CONTROL

Fully automatic positioning of the boring head and column can be obtained when the punched-tape control system is in operation. An eight-bank binary code punched-paper tape is used, and Fig. 3 shows a close-up view of the tape-reading mechanism, which is fitted on the rear of the column. The first stage in producing the tape is to prepare a comprehensive operations sheet from a working drawing of the part to be machined, including information regarding any special methods or tooling to be employed. This operations sheet includes general information concerning the workpiece, such as the part number and name, and divides the complete machining sequence required into separate operations. The vertical and horizontal ordinates for each hole are specified, as are the speeds and feed rates required, the type of tool to be used, and, where necessary, the depth of hole to be bored or drilled. A space is also provided on the operations sheet for the

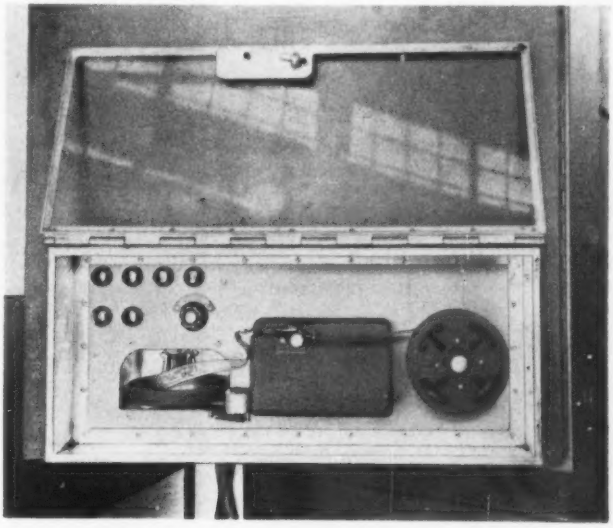


Fig. 3. Close-up View of the Tape-reading Mechanism Fitted on the Rear of the Machine Column. An 8-bank Punched-paper Tape is Employed

inclusion of number references for special tools.

A copy of this operations sheet is then typed on a machine which simultaneously punches the tape, and, after a further copy has been made, the two sheets are compared for errors. The punched-tape and operations sheet are next issued to the operator who, after loading the tape in the reading mechanism, selects "tape control" on the master rotary switch of the control panel. The machine is now ready to operate under the control of information supplied by the tape. At the end of each complete, and separate, operation, the boring spindle is automatically retracted, and the traverse button must be pressed before the machine members will proceed to the next location. A number of pilot lights are mounted on the control panel, which indicate when the tape is ready to run; if the tape has contained an error; and when the tape has finished transmitting. These pilot lights are duplicated on the tape-reading unit.

MEASURING EQUIPMENT

The measuring equipment used on the machine is of the electronic scale design, known commercially as Inductosyn, and already described in MACHINERY, 90/1062—10/5/57. This system was chosen because of the need to measure automatically to within 0·0001 in., and to maintain this degree of accuracy irrespective of errors caused by misalignment of the machine members, or wear of the sliding parts. The electronic scale is of glass, and is assembled in 10-in. long sections with an air gap between each section, thus reducing the possibility of the overall accuracy being affected by thermal expansion. An electronic slider, for measuring the current in the scale, also operates across an air gap so that no wear can take place between these two parts.

The measuring equipment must be set in relation to the datum hole of the first workpiece of any batch, and after the boring spindle has been manually aligned with this hole, the electronic measuring system can be adjusted to zero. This procedure is necessary for the first workpiece when the machine is being operated by either the digital dial or the tape-controlled system. The machine illustrated in Fig. 1 has a horizontal travel of 240 in., and a vertical travel of 84 in. It may be noted, however, that the Kaukauna triple-control system, incorporates Inductosyn equipment capable of continuous measurement over a distance of 400 in., which, it is believed, will cover all normal machine tool requirements.

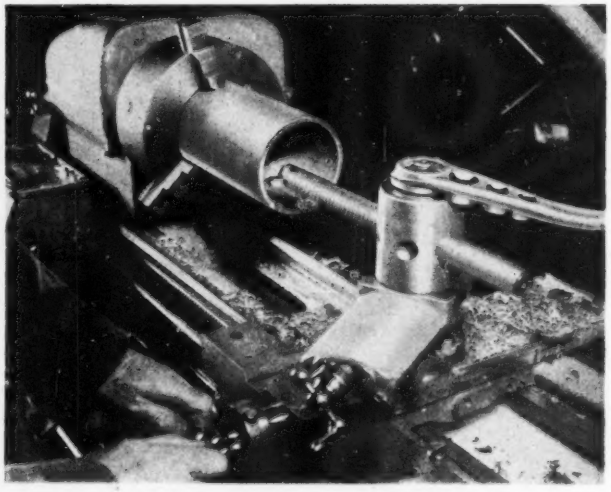
It is claimed that the ease with which control of the machine can be changed from one system to another will enable machine shops, which adopt this equipment, to gain the advantages of automatic machining without sacrificing any of the versatility inherent in their standard machine tools.

The Giddings & Lewis Machine Tool Co. are represented in this country by the Rockwell Machine Tool Co., Ltd., Welsh Harp, Edgware Road, London, N.W.2.

Penso Chatterless Boring Bar

The boring bar seen in the figure has recently been introduced by Penso Products, U.S.A., and is claimed to be effective in reducing chatter and vibration. This bar is bored out from both ends to various diameters, with the smallest at the centre, to diminish harmonic vibration. Optimum bore diameters at various positions were determined by the use of a vibration meter. The bore is finally filled with a shock absorbing material under vacuum, and the ends are sealed.

A special alloy steel is employed for the bar to provide the necessary torsional rigidity for taking heavy cuts at high speeds, and the surface is graduated at ¼-in. intervals to facilitate measurement of bore depth.



Penso Boring Bar of a Special Design which is Claimed to Reduce Chatter and Vibration

Modern Presswork Techniques*

By T. G. WOODWARD†

Developments that have taken place in presswork techniques during recent years have further extended the fields of application. Some of the most important developments have been concerned with the use of multi-stage (progressive) tools, transfer presses, and mechanical handling equipment for connecting standard presses, also mechanization of a general nature, which may involve various types of machine tools. It is with multi-stage tools that we are here principally concerned, and transfer presses will be considered in a second article.

MULTI-STAGE PRESS TOOLS

To ensure an accurate product and an efficient strip layout when multi-stage tools are used, it is necessary to follow a definite procedure during the early design stages, and the following sequence is recommended. (1) Develop the blank. (2) Establish a provisional sequence of operations, taking into consideration the strength of the die, and introducing idle stations where required. (3) Determine the method of "webbing up" for retaining the blanks in the strip. In this connection, it should be noted that the direction of grain will affect the final economic layout of the blank in the strip. It is most important that due thought should be given to this stage. In some instances it may prove advantageous to employ different material from that originally specified, or a different direction of grain, in the light of previous experience with similar workpieces. Location of the blanks with respect to grain-direction may be influenced by subsequent bending or welding operations, also by the accuracy and function of the workpiece. (4) Consider the relationship of any burrs to bends in the workpiece, particularly if a curling operation is required. When such an operation is carried out, burrs should always be on the inside of the curl. (5) Give attention to the gimping of the strip for feeding purposes. With light-gauge work-materials, gimping is not generally necessary, but with thick metal or heavy strip material, gimping is essential if broken punches and pilot pins are to be avoided. Since material at least equal to the stock-thickness must be allowed along the edge of the strip, gimping has an important bearing on the width of strip employed. (6) Decide upon the most convenient position for holding the blank in the "webbing." A position that is suitable for progressing the blank through all operation stages requires some thought, since no loose pieces of strip must be left on the die face. At times, it is necessary to pierce holes in the webbing to receive pins for piloting or tracking purposes. Such pins must be provided at the second and final stages, and at intermediate positions, as required. (7) Consider whether it would be advantageous to provide a "starting" stop, particularly when a tool is used on a roll-feed press. Such a stop prevents the formation of part-blanks and half-holes which make successful starting and feeding of the strip difficult, and may result in breakage of fragile punches, and excessive maintenance costs. (8) Carefully study the proposed strip layout, to ensure that the most economical material utilization is achieved, and investigate the possibility of producing a different workpiece from the waste "webbing." When all these considerations have been taken into account, the width of coil or strip material, and the pitch of the blanks, can be determined.

EXPERIMENTAL TOOLING

The most satisfactory method of checking the correctness of the estimated blank size, and the proposed method of producing a workpiece on a multi-stage tool, is by try-out, using a set of experimental tools. Such tools should be designed for use in a hand or wheel press, and should be left in the soft condition for development purposes, unless it is absolutely essential that they should be hardened because of the work to be undertaken. If the design of the multi-stage tool has reached an advanced stage, provision may be made for the inclusion of experimental units in the finished tool.

The design of the experimental tools should be such that the method of production conforms exactly to that visualized for the final tool. The experimental tools are then used to carry out forming operations on a series of blanks in a test strip, which may be made by the following procedure. Using a guillotine, a strip of work material, of the

* Based on a paper presented at the Annual Conference of the Institute of Sheet Metal Engineering, October 30–31, 1957.

† Joseph Lucas (Electrical), Ltd.

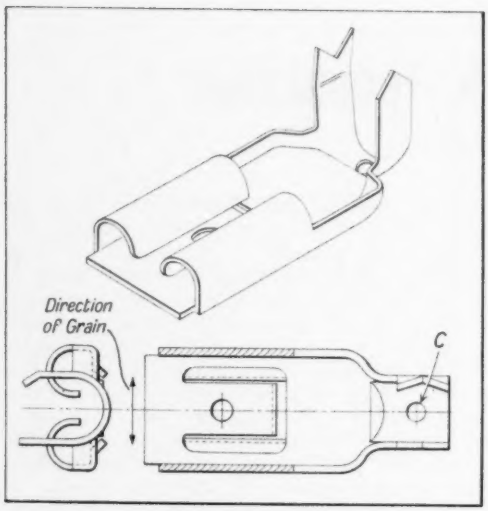


Fig. 1. Views of a Component to be Produced from Phosphor-bronze Strip, in Large Quantities

correct thickness and specification, is cut to the required width and length. All circular holes which would normally be produced by the punches of the multi-stage tool are drilled to the dimensions given on the proposed strip layout. A series of blanks is marked out on the strip at the estimated progression-distance, after which any gimps, cut-outs or shaped holes are produced by sawing to the layout dimensions. Blanks attached to the "webbing" are thus obtained for use with the experimental tools.

This test strip can now be located on each experimental tool by means of the drilled pilot holes, and the blanks formed to shape in the correct sequence. By this method, a completed length of formed parts and "webbing" is obtained, which gives all the necessary data for the final design of the multi-stage tool. It is considered that the procedure described is essential for determining the blank-dimensions and the number of draws required for the production of drawn components, and should always be followed for any tool where one or more drawing stages are involved.

The method may be illustrated with reference to an actual workpiece, such as that shown in Fig. 1. This pressing is to be produced in phosphor-bronze material, 0·014 in. thick, and it may be noted that the direction of grain is stated, so that one of the essential factors governing tool design has been finalized. Fig. 2 shows the lay-out of a test strip with all the necessary holes drilled and the surplus material cut away, so that the series of blanks is left attached to the webbing provided for feeding purposes. It should be mentioned that the trial dimensions for the actual blanks are checked by practical tests, and are adjusted, if necessary, before the strip is cut.

The series of operations which was considered necessary to produce the component is shown diagrammatically in Fig. 3. The various stages are as follows: operation 1, slit and raise; operation 2, nib; operation 3, first raise; operation 4, second raise; and operation 5, roll. To establish that this theoretical sequence and strip lay-out were correct, a set of cheap experimental tools was made, and the tool for the first operation (slit and raise) is shown in Fig 4.

This tool was designed for use on a wheel press, and, in operation, the test strip was placed on the top face of the die, where it was located by the two pins *A* and *B*. The ram of the press was then moved downwards, and the blank on the strip was formed between the punch and the die. Next, the workpiece was checked to determine whether the blank had been formed to the correct shape for this stage.

Subsequently, the partially-formed strip was located in an experimental nibbing tool, using the same method of location as in the slit and raise tool, and the workpiece was formed between the punch and the die, so that a nib was produced on each side of the blank. These nibs later formed the inner ends of the rolled ears at the sides of the workpiece, after they had been completed in the tool for operation 5. After the nibbing stage, the test strip was transferred to an experimental first-

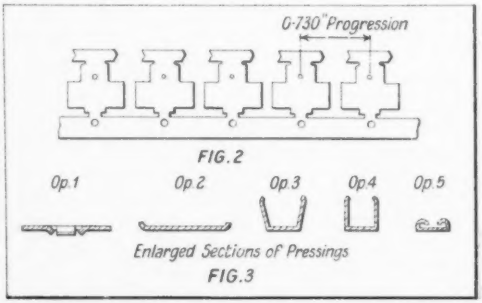


Fig. 2. Layout of Experimental Strip of Workmaterial, with Holes Drilled and Excess Material Cut Away, which is Used for Proving the Operation Sequence and Strip Layout for the Workpiece Shown in Fig. 1

Fig. 3. Diagrammatic Views of the Operations Carried Out on the Experimental Strip, Fig. 2

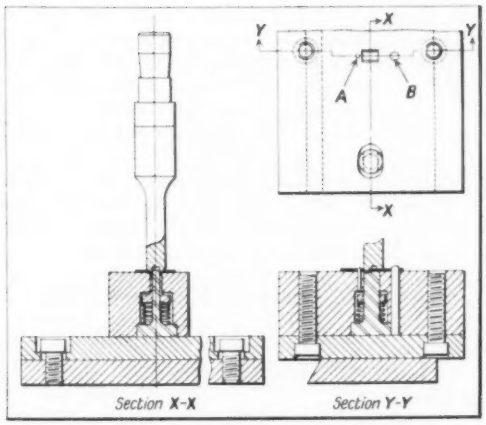


Fig. 4. An Experimental Slit and Raise Tool Used for Try-out Purposes

raising tool, Fig. 5, where the method of location was similar to that employed at the preceding stages. The first raising operation was considered essential when the strip lay-out was planned, but was shown to be superfluous by the trials in the experimental tools. In practice, it was found that the nibbing operation was sufficient to ensure a good form after the final rolling stage. Originally, it was intended that the first raising tool should form the material sharply at the junction of the ears and the body of the part, so that there would be less work to be performed by the second raising tool, since it appeared that the form of the punch at this stage would not allow the sides of the workpiece to rise squarely.

As already indicated, a satisfactory workpiece was produced by a single raising operation, and although the nib portion was wrapped round until it engaged the punch, it was found possible to withdraw the latter member without deforming the component, since the material sprang back to the true form.

The part was finally formed to shape in the rolling tool, Fig. 6, whereby the ears were bent as shown in Fig. 3, operation 5. This stage completed the experimental work, as, in practice, the coil of work material is run through the multi-stage tool without cropping off the finished components, to suit production methods which have been recently introduced by the author's company.

From the results obtained with the experimental tools, it was possible to design a multi-stage tool with every confidence in its ultimate success, and the initial work ensured that many " false starts " were eliminated. In accordance with the practice generally adopted at the works with which the author is associated, the final tool was of the 4-pillar type, for use on a C.V.A. high-speed dieing press, and is shown in Fig. 7. The strip is fed from right to left, and the lower tool has been arranged so that there are individual units for the various stages, to facilitate grinding, maintenance and adjustment. In addition, a number of idle stages has been introduced to simplify the work of tool making. For piercing the 0·046-in. diameter hole (C, Fig. 1), a " whip-sleeve " straight-ground punch is fitted, which is arranged to slide in a sleeved stripper, mounted in the main stripper plate. At the forming stages, the strip rides over the die sections, assisted by spring-loaded strip guides, in the lower tool. To stop the strip from picking up on the pilot pins, with the consequent

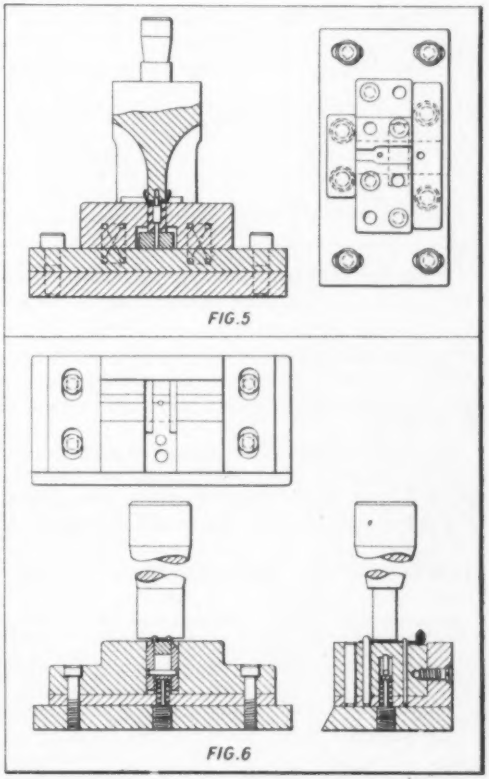


Fig. 5. Experimental First-raise Tool Used for the Strip in Fig. 2

Fig. 6. Experimental Rolling Tool for the Final Stage on the Experimental Strip

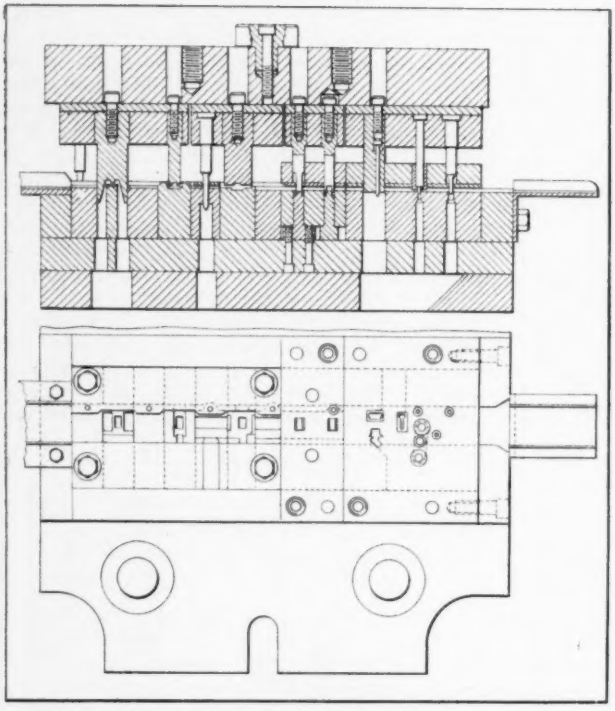


Fig. 7. The Final Multi-stage Tool for the Production of the Connector, Fig. 1.

formation of buckles, a small additional stripper section has been introduced. This section surrounds the pilot-pins which are not accommodated in the fixed stripper.

In Fig. 8 is shown the strip lay-out for the final multi-stage tool. Two pilot holes are pierced at stage 1, and the 0·046-in. diameter hole, also the elongated slot, at stage 2. Next, at stage 3, the gimp and slot are produced, and the workpiece is slit and raised at stage 5. Stage 6 provides for dimpling and setting the centre-portion of the workpiece, and the next stage, No. 7, is idle. The nibs are formed at stage 8, which is followed by an idle stage, before the raising operation is carried out at stage 10. Another idle stage follows and the workpiece is finally rolled to shape at stage 12.

METHODS OF BLANK RETENTION

The simplest form of multi-stage tool provides for follow-on piercing and blanking, and this type of tool was probably the first to be used. With tooling which represents an elaboration of this simple form, pressure is applied to the workpiece from below, at the blanking stage, so that it is thrust back into the strip of work-material. The blank will only enter its own aperture in the strip for a distance equal to one-third of the material thickness, but this is usually sufficient to secure the blank in the parent stock, for transfer to the next stage of the tool. Here, the workpiece is planished firmly into the strip, and subsequently it is bent and formed as may be required, and ejected from the strip at the final tool stage.

This method of blank transfer is more effective for thicker materials, since there is a tendency for thin material to buckle, crease or bend, so that the blank may be released, and thus remain in a tool-stage when the strip is advanced, with disastrous results. There is always a danger, moreover, when it is not possible to guarantee that

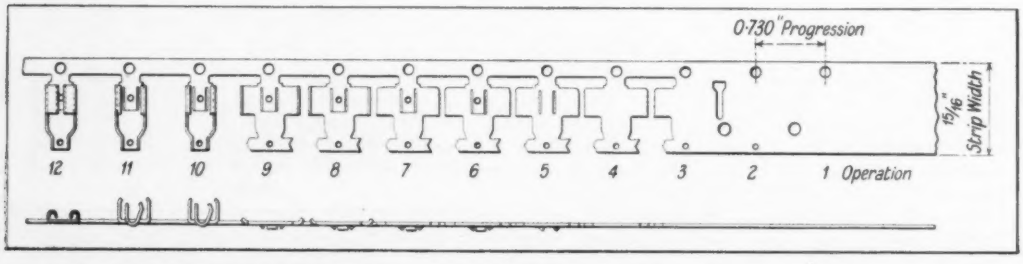


Fig. 8. Layout of the Strip Produced in the Multi-stage Tool for the Connector Component. Idle Stages are Incorporated to Increase Tool Strength and to Facilitate Toolmaking

the strip will start with a full aperture—due to the shape of the blank or the interlacing of the workpieces to obtain good material utilization—that a blank will fall out of the strip at a bending stage, as a result of insufficient grip being applied by the surrounding material.

Another method for transferring blanks involves cracking the work-material only round the part of the blank that it is required to form, so that the remainder of the blank is firmly secured to the strip. This method seems suitable for thinner-gauge materials, but presents certain difficulties with thick material. For example, whereas a working drawing of a symmetrically-shaped part may indicate a 90-deg. bend, there is a definite crowding of the metal at the corner of the actual workpiece, with the result that the width is increased above the specified size. Moreover, if the entire side of a component is to be raised, it is necessary for the forming punch to slide through the aperture produced by cracking. In consequence, the forming punch often acts as a shaving tool, and cuts slivers of metal from the edges of the aperture.

A third method involves the removal of the work-material round those portions of the blank on which further operations are to be performed, instead of cracking as just described. This removal of material affords complete freedom from the difficulties associated with the cracking method, and considerably facilitates tool design. It gives rise to other problems, however, since additional material must be provided to allow for the clearing-away stage, and it might possibly be necessary to increase the pitch of the work-stages. Moreover, the slender form of the piercing punches often necessitates the use of segmental dies for more than one stage, in order to facilitate tool maintenance, with a consequent increase in tool cost.

Where drawing operations are to be performed, a fourth method, which depends on double cracking, is particularly effective. It is necessary to make available work-material of a sufficiently large area for the production of the drawn cup, and to ensure that, although this area is free to move, it is attached to the parent material during movement through a multi-stage tool. An operation similar to blanking is performed at the first tool stage, but the die is stoned away at four positions, in order to prevent actual separation of the blank from the strip. A similar operation is carried out at the second tool stage, but there, the tools are slightly smaller, and the stoned away portions are located at 45 deg. in relation to those of the first stage. As a result, two concentric series of arcuate cracks are produced, and the blank can move freely, but is firmly attached to the parent metal.

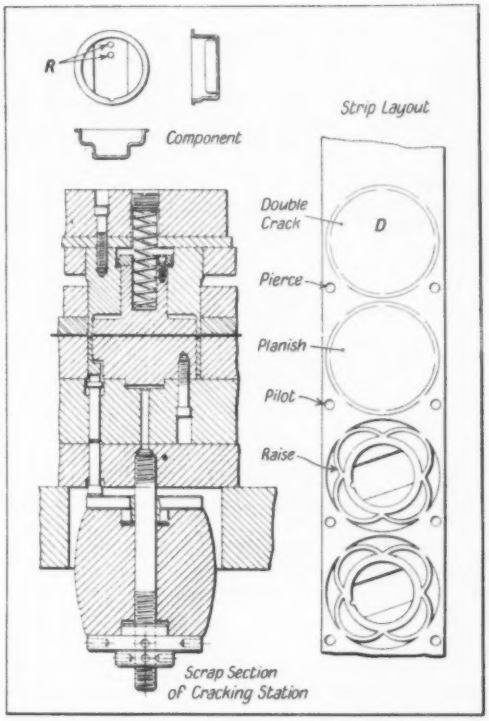


Fig. 9. A Mild Steel Switch Housing (upper right) with the Strip Layout for Producing it, and the Tool Members for the Double Cracking Operation

This method is employed for the mild-steel switch housing shown in Fig. 9. It is often possible to combine the two cracking operations in one tool stage, as indicated in the strip layout at *D*, Fig. 9, provided that the radial distance between the two sets of concentric cuts is sufficient. The tool for producing the double crack at the first stage in the production of the workpiece is also shown in Fig. 9, and it will be evident that the distance between the inner and outer cuts must be such as to permit the use of tool members of adequate strength. For material up to $\frac{1}{8}$ in. thick, $\frac{1}{4}$ in. of metal between the concentric cracks usually suffices. It should be emphasized, moreover, that double cracking should be followed immediately by a planishing stage, to flatten the blank so that the drawing pressure that is applied subsequently is distributed evenly over the whole of the blank area.

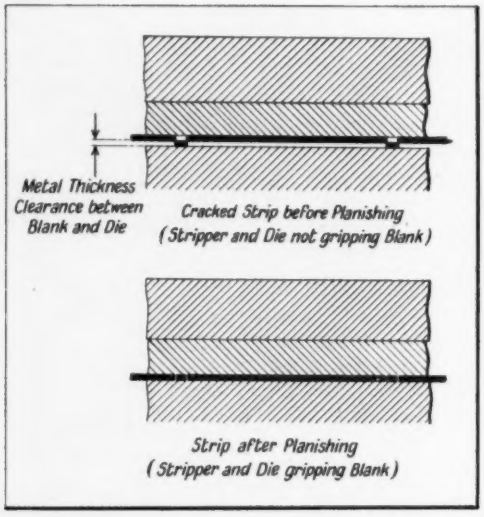


Fig. 10. The Importance of a Planishing Stage after Double Cracking is Here Indicated Diagrammatically

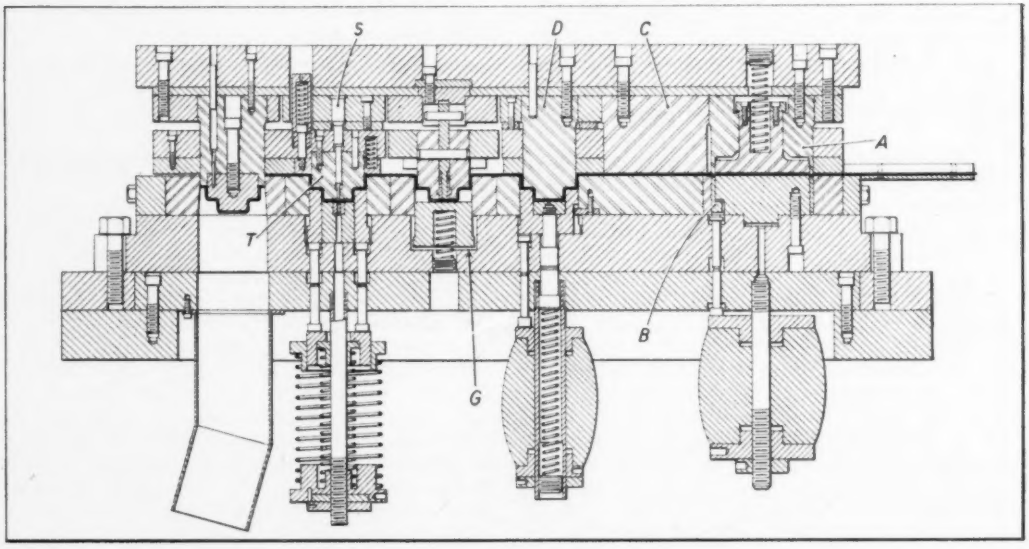
The importance of the planishing operation will be evident from Fig. 10. In the upper view, the strip is shown before it has been planished, and it will be seen that the stripper and die do not grip the blank, due to the projection of the four annular ties below the body of the strip, so that wrinkles would be formed at the drawing stage. The planishing operation forces these ties back into the strip, as indicated in the lower view.

MULTI-STAGE TOOL FOR SWITCH HOUSING

A multi-stage tool for the production of the switch housing (Fig. 9) from mild steel, 0·036 in. thick, is shown in Fig. 11. At the first tool stage, double cracks are produced in the material by the annular die opening, in conjunction with the punch *A* and pressure pad *B*, in order to release the blank for subsequent drawing operations. The pilot holes at the sides of the strip are also pierced. The tool members at the second station, one of which is indicated at *C*, planish the strip, so that the annular portions between the cracks are pressed back into the work material, location being provided by pilot-pins, which enter the previously-pierced holes. As the workpiece is drawn at the next stage, it is necessary to produce the die in two sections, to facilitate regrinding the drawing and cutting portions.

Enlarged views of the tool members at the drawing station are given in Fig. 12. The drawing operation is carried out in two stages, and at the left in Fig. 12, the tools are shown at the end of the first stage. In the view at the right, the

Fig. 11. A Multi-stage Tool for the Production of Switch Housings from Mild Steel Strip



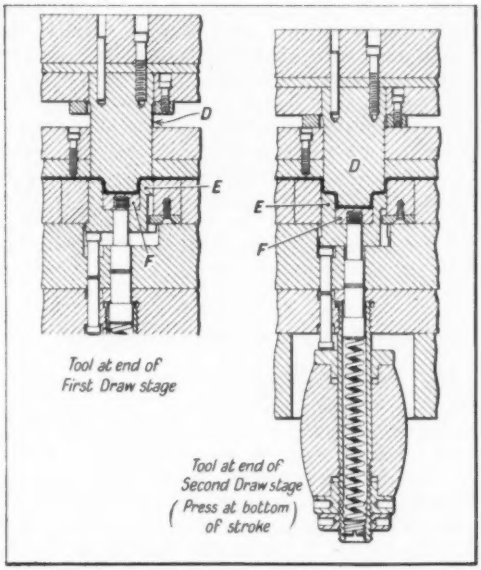


Fig. 12. The Tool Members at the Drawing Stage of Fig. 11, are Here Shown (right) at the End of the First Stage, and (left) at the Completion of the Drawing Operation

second stage has been completed, and the press is at the bottom of its stroke. The blank is held against the die by the action of the spring-loaded stripper incorporated in the tool, and as the punch *D* descends, the inner raised portion of the workpiece is produced. The outer ejector *E* is connected to a rubber buffer which exerts a powerful upward pressure. Consequently, the drawing thrust is resisted until the workpiece is gripped between the punch and this outer ejector. At this stage, the inner ejector has been thrust downwards to the bottom of its seating in the outer ejector. Further punch movement then forces the outer ejector positively downwards, so that the outer drawn form of the workpiece is obtained. Finally, the outer ejector contacts the bottom of its seating in the lower tool, as indicated in the right-hand view of Fig. 12, and the step on the workpiece is planished between the outer ejector and the punch.

At the fourth tool stage, a hole is pierced horizontally in the side of the drawn component by means of a punch which moves outwards. The tool members for this stage are indicated at *G* in Fig. 11, also in the enlarged cross-sectional view, Fig. 13. An independent stripper plate *H* is incorporated, which is heavily spring loaded, and carries a housing for the horizontal punch mechanism. The housing is machined at its lower end to provide a cruciform guideway, in which slides a punch holder of corresponding cross-section. This holder is indicated at *J* in Fig. 13, and a short piercing punch is fitted in a hole at its left-hand end, and secured by a threaded retaining pin. A lever *L* is pivoted in the housing, and its lower end enters a slot in the punch holder *J*. A transverse pin projects from either side of the lever at the upper end, and enters cam-slots in the U-shaped block *M*, fitted to the upper tool.

As the upper tool descends, the housing enters the drawn workpiece to locate it correctly relative to the lower tool, and then thrusts it downwards into the die, against a spring-loaded ejector *P*. The downward movement of the stripper plate *H* is arrested by the guide bars at either side of the lower tool, so that the horizontal punch is located correctly relative to the associated die *N*. As the upper tool continues to move downwards, the upper end of the lever *L* is moved sideways by the action of the cam-slots in the block *M*. In consequence, the lower end of the lever thrusts the punch holder to the left, and the punch pierces the hole in the side of the workpiece. During the first part of the return movement, the horizontal punch is withdrawn as the upper tool moves away from the spring-loaded stripper plate *H*, and the workpiece is finally lifted out of the lower tool by a

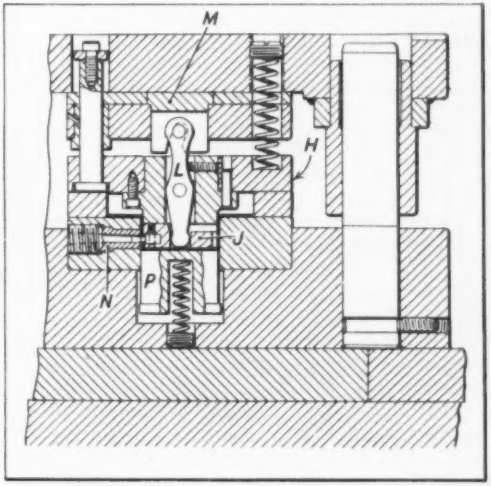


Fig. 13. This Tool Assembly is Incorporated in the Multi-stage Tool, Fig. 11, and Provides for Piercing a Hole in the Side of the Workpiece

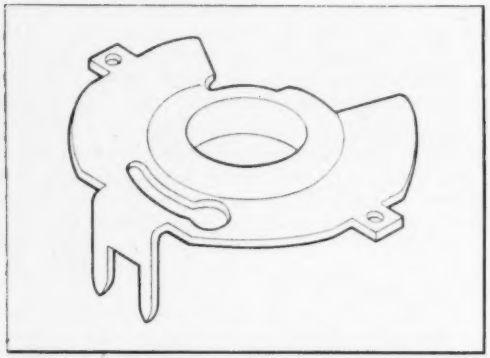


Fig. 14. Perspective View of a Mild Steel Bearing Plate, Made from 0·060-in. Thick Strip

spring-loaded ejector indicated at *P* in Fig. 13.

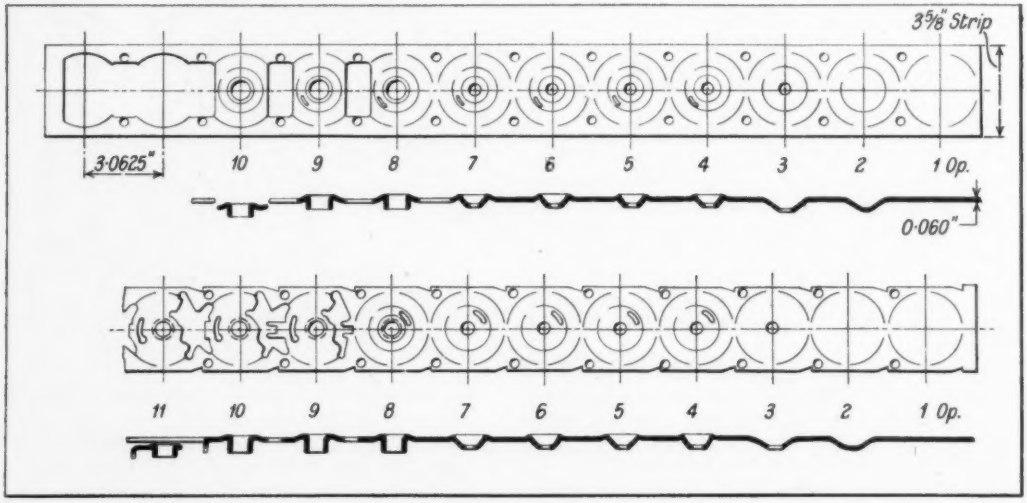
At the next tool stage (number 5), two small holes, *R* Fig. 9, are pierced in the workpiece by conventional punches, one of which is indicated at S in Fig. 11. These punches pass through the final forming punch *T*, which "sharpens up" the component. The form punch *T* is secured to the stripper, and the latter member comes in contact with a hardened steel plate, fitted to the main punch carrier, as the press approaches the bottom of its stroke. In this way, the tool members at this stage are made "solid," and the workpiece is formed between the punch *T* and spring-loaded, and fixed, forming dies in the lower tool. A separate auxiliary stripper ring surrounds the punch *T*, and this ring is spring-loaded downwards.

The workpiece is sheared from the strip at the sixth station, and passes down a tubular guide to a work-pan below. At this station, the die has a parallel land, which extends to a depth of $\frac{3}{8}$ in. from the top face, and below this land the die is machined to provide a clearance of $\frac{1}{32}$ in. round the form. The punch passes through the die to a position beyond the end of the parallel portion, and the "spring" of the work material ensures that the piece is stripped from the punch by the shoulder face in the die, as the ram of the press rises.

MULTI-STAGE TOOL FOR BEARING PLATE

Fig. 14 is a perspective view of a bearing plate, which is produced from No. 1, deep-drawing quality, mild steel, 0·060-in. thick. This workpiece must be made to close limits of accuracy, and the method proposed for its production was checked by means of inexpensive experimental tools. The design of the final progressive stage tool was based on the results thus obtained. In Fig. 15, the layout of the strip of work-material used in the experimental tools is shown at the top, with the final strip layout below. No experimental tooling was provided for stage 1, cracking;

Fig. 15. The Layout of the Strip of Work-material Used in Experimental Tools for Proving the Production Methods for the Bearing Plate is Shown Above, and the Final Strip Layout Below



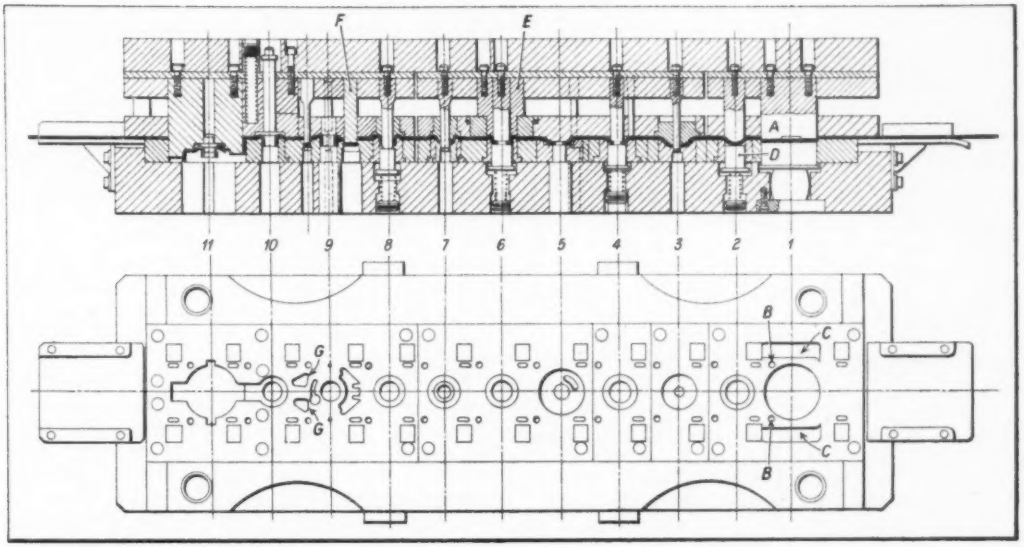


Fig. 16. The Final Multi-stage Tool for the Production of the Bearing Plate, Fig. 14. The Design is Based on the Results Obtained with Experimental Tools

stage 5, pierce elongated hole; or stage 9, cut-away sides.

A sectional view of the final tool is given in Fig. 16, also a plan view of the die portion. The sequence of operations is as follows. At the first stage, four arcuate cracks are produced in the strip by the punch *A*, the cracks being located beyond the area required for the finished component. The strip is supported on a planishing member, in the lower tool, which is urged upwards by a rubber buffer. In this instance, cracking reduces distortion of the strip during subsequent operations, and ensures that the pilot holes are maintained in true alignment both longitudinally and transversely. The pilot holes are also produced at the first stage by punches *B*, at either side of the tool, and to facilitate accurate feeding, notches are cropped in the sides of the strip by the punches *C*. It will be observed that the complete tool is divided into convenient units, with inserts where required, to facilitate adjustment and maintenance.

At the next stage, the first raising operation is performed, and it is essential that the workpiece should be free from wrinkles, without undue stretching or thinning of the material. As a result of the previous cracking operation, the metal can pull inwards as it is deformed, and wrinkling is controlled by a spring-loaded pressure pad. After being formed, the work is ejected from the lower tool by the action of the spring-loaded plunger *D*. At this stage, one pilot pin is arranged to serve as a monitor in order to guard against mis-feeding of the material, in a manner that will later be made clear.

The round hole in the centre of the workpiece is produced, at stage 3, by a conventional punch and die. This piercing operation facilitates the work at the next stage (4) which consists of flattening the under-side of the raised portion, and pushing back the work material around this portion, slightly above the level of the die, as a preliminary stage in forming the finished raised shape. Spring-loaded strip lifters are used throughout the tool, and operate on the outside of the "webbing." These lifters, in conjunction with individual ejectors at the raising station, ensure that the strip can feed freely.

At stage 5, an arcuate slot is pierced in the strip in a position that was locally flattened at the fourth stage, and the work material is cleared from the piercing punch by a spring-loaded stripper. Forming of the 12-deg. conical shape is completed at stage 6, and a cup is also produced, which is of the correct outside diameter, and of sufficient depth to allow for subsequent plunging. The punch, indicated at *E*, is made in two pieces to facilitate adjustment. At stage 7, the centre hole is re-pierced to a size determined during the preliminary try-out. This size is such that the work-

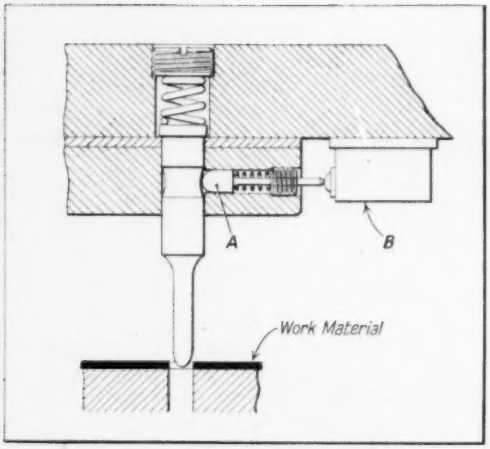


Fig. 17. This Floating Plunger Acts as a Pilot and Serves to Guard Against Mis-feeding

piece will be of the required depth after the plunging operation at stage 8. At this latter stage, in addition, the whole of the top face of the workpiece is again planished.

Punches at stage 9 produce one slot, of a curved key-hole shape, and a small round hole at either side. At the same time, the punch *F* pierces the material to form the shape at one side, also the two prongs of the bifurcated lug on the following component. In addition, at station 9, material is cut away from either side of the lug, by the punches *G*. The lug is bent downwards at stage 10, and the outer edges of the workpiece are planished. The die portion of the tool is cut away between stages 10 and 11, so that the bent lug can advance freely, and so that one punch can be used both for final blanking and bending of the lug. The material is fed from a coil, and the press runs for periods of 45 min. without an operator.

The effectiveness of progressive (multi-stage) tools is considerably enhanced if some forethought is given to their installation and associated equipment. Efficiency can easily be reduced if due attention is not paid to the separation of scrap and finished components, and it is important that all progressive tools should be equipped with chutes to deflect scrap into separate containers. When the components produced are small, it is only necessary to provide receiving trays beneath the blanking stage to collect the workpieces. If heavy or large workpieces are being made, however, the problems associated with work-removal cannot be solved so readily, and it may be necessary to install conveyors beneath the presses to collect and transport the components either to mobile hoppers or direct to the assembly lines.

TOOL PROTECTION

When tools of the type described are used, it is important to provide protection against mis-feeding, buckling of the work-material, and incorrect initial positioning of the strip, all of which may cause damage to the tool members. Equipment should be installed to stop the machine if necessary—for example, an electronic unit known as an automatic monitor—and may be used in conjunction with one of the following sensing arrangements.

The floating plunger shown in Fig. 17 provides a safeguard against mis-feeding. At its lower end, the plunger is 0·020 in. smaller in diameter than the corresponding tracking hole in the strip. It is located in the tool so that it can move downwards into the associated hole in the lower tool, when the strip has been correctly fed. If the strip should be out of position by more than 0·020 in., the lower end of the plunger comes in contact with the strip as the upper tool descends. As movement continues, the plunger is held stationary, and the spring-loaded pin *A* is moved sideways to trip the limit switch *B*. This switch is connected to the control unit of the machine, and the latter is arranged to throw-out the clutch, which, for satisfactory operation, must be of the plate type. A clutch of this type fitted to a 200-ton press, it may be noted, disengages the drive in seven-eighths of the 4-in. stroke movement, when the press is running at 120 strokes per min.

An arrangement for stopping the press in the event of the material being buckled consists of a pivoted arm, which is located so that its lower

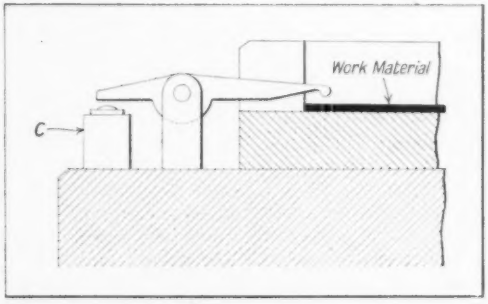


Fig. 18. Buckling of the Work-material can be Detected by this Sensing Finger, which Trips a Micro-switch

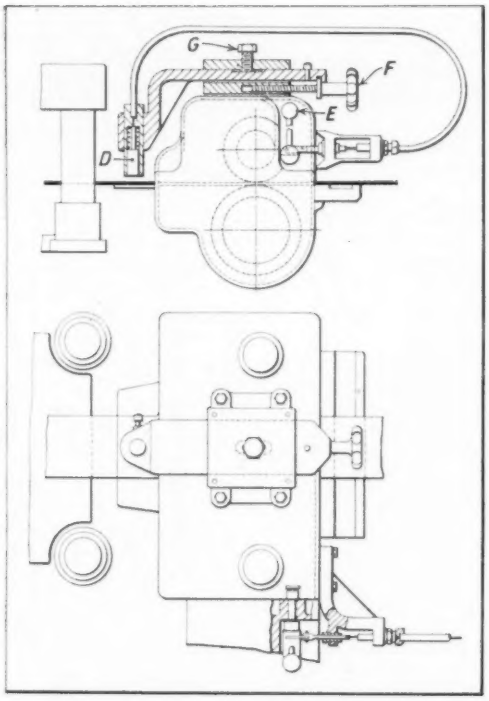


Fig. 19. This Starting Stop has been Designed for Use on Presses with Double Roll Feed Mechanisms, and Enables the Strip to be Accurately Positioned Initially

end rests on the work-material, at a position between the entry pair of feed rolls and the tool. If the material is buckled, the arm is tilted and a micro-switch is tripped, which, through associated control gear, disengages the clutch of the press. A somewhat similar arrangement can be employed to detect folding of the work-material after a drawing operation, due to the workpiece sticking in the die. Two small pivoted arms are fitted to the bottom tool at either side as shown in Fig. 18. If the material starts to fold, the inner end of the arm is raised, and a micro-switch *C* is tripped. Again, it is necessary for the press to be fitted with a plate-type clutch, such as are used on modern dieing or double-roll feed machines.

SPECIAL STARTING STOP

The starting stop shown in Fig. 19 has been specially designed to facilitate initial setting of the strip of work-material in the correct position. It is operated from outside the entry rolls, and this arrangement is obviously superior to that for the normal type of stop, which is usually located within the tool, and is thus hidden.

On the type of press to which this stop is usually applied, the top feed roller can be lifted while the press is running. It can be held in the raised position by means of a spring latch, or released by operation of a small hand lever. The stop member *D* is spring-loaded downwards, and is connected by a Bowden cable to the suitably-modified hand operating lever *E* for the upper roll. Movement of the stop is thus synchronized with that of the upper roll, the roll being raised when the stop is lowered, and vice versa.

The horizontal position of the stop can be set relative to the first station of the tool by means of the adjusting screw *F*, and it can be clamped in position by the screw *G*. It is set so that a complete blank-stage is produced on the strip during the first working stroke of the press.

Arrangements of the type outlined enable a press shop to be operated in a similar manner to a modern single-spindle or multi-spindle automatic department. An operator for each press is not required, since he cannot contribute either to output or quality, nor is he able, generally, to guard against tool breakages. In this connection it may be pointed out that the majority of accidents to tools occur during the first mis-feed of the material, before the press-minder can intervene.

USE OF COMPRESSED AIR

Some reference should be made to the use of air-operated units in multi-stage tools. In one instance, a 6-stage tool is used for operations on work-material 0·110 in. thick and 4 in. wide. At one drawing stage, it is necessary to eject the pressing from a recess, but the ejector has to be moved clear, to allow the following component to enter. The arrangement adopted is shown in Fig. 20, and it will be seen that a 3-in. diameter air cylinder *H* is built into the lower bolster, directly beneath the drawing stage. A plate is mounted on the piston rod of the cylinder, and thrust is imparted by this plate to pins, as indicated at *J*, and thence to the ejector *K*. Air is directed to either end of the cylinder by a standard double-acting valve, mounted on the bottom bolster, and this valve is actuated by a lever on the ram of the press. The timing of the ejection motion can be adjusted, as required, by modifying the relative positions of the lever and valve.

Another example of the use of compressed air is afforded by the operation of a planishing mandrel, which has to move in phase with the operation

cycle, when the work-material is stationary. The arrangement is shown in Fig. 21, and provides for the production of flanged tubular components, from 0·030-in. thick mild steel. The tool is used on a roll-feed press, and the required travel of the mandrel considerably exceeds the stroke of the press, so that the provision of a mechanical linkage would have been difficult.

A 2½-in. diameter air cylinder *L* is coupled to a sliding member, whereon are mounted the mandrels *M*, *N* and *P*, for forming the pressing to a U-section, rolling, and setting, respectively. As the first half of the downward movement of the press ram is completed, an air valve on the tool is tripped, and the piston of the cylinder *L* is advanced to carry the mandrels into the working position. At the start of the return stroke, the valve setting is reversed, and the piston and mandrels are withdrawn, before the work-material is advanced. Applications of this type are not recommended when presses which operate at high-speeds are used.

A number of benefits may be derived from the use of multi-stage progressive tools. Firstly, output is greatly increased, compared with that obtainable with single-stage tools; secondly, work-handling is reduced to a minimum, so that not only are there savings in transport costs and storage space, but safer operating conditions are ensured, since the movement of workpieces into and out of presses

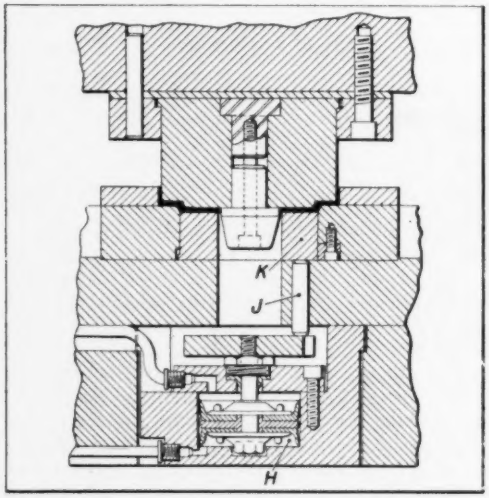


Fig. 20. An Air-operated Unit Developed for Ejecting a Workpiece from a Drawing Tool. The Ejector is Moved Downwards to Allow the Next Blank to Enter

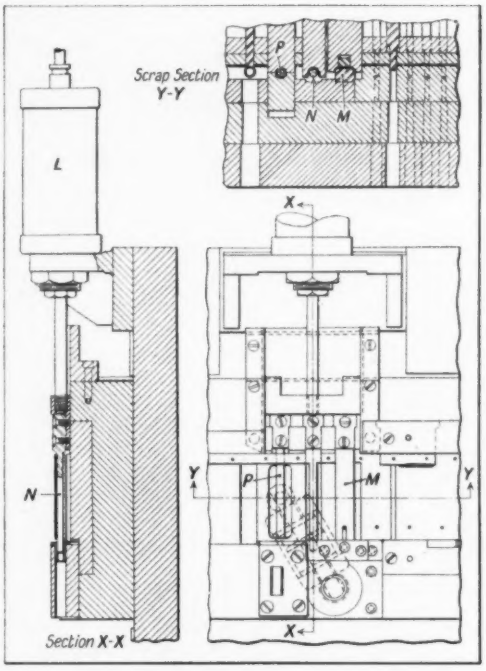


Fig. 21. Three Mandrels Mounted on a Slide are Advanced and Withdrawn, when the Work-material is Stationary, by means of the Air Cylinder Indicated at *L*

is eliminated or reduced to a minimum; thirdly, very high standards of quality can be maintained, and errors due to the human element are practically eliminated.

A further article based on Mr. Woodward's paper, and dealing with transfer presses and tooling, will be published shortly.

A PAINT TUMBLING MACHINE, which was designed by Mr. R. Anderson, M.I.Plant.E., chief engineer of E. Atkins, Ltd., Alperton, Wembley, Middlesex, and built at a cost of £300, is said to have effected important savings in the time required for preparing the paint.

Previously, each operator engaged in spraying spent 40 min. per day, on average, stirring drums of cellulose and cans of filler. The new machine, which is driven by a ½-h.p. motor with push-button control, will accommodate four 5-gal. drums of cellulose and two 17-lb. cans of filler, the contents of which are tumbled and kept ready for immediate use by the paint-spraying operators.

Machining Operations on Pontiac Stub Axles

By L. B. ARSCOTT*

The stub axle for use with the ball joint suspension system on the 1958 Pontiac car has been redesigned so that the stub axle and support member are combined. Stub axles are forged from SAE 1345 steel, and after inspection, the forgings are heated to 1,550 deg. F. in a continuous gas-fired furnace, quenched in oil, and tempered to obtain a Brinell hardness of 241 to 286.

Both the yoke and stem ends of the stub axle are spot-faced and centre-drilled on a Seneca Falls Lo-swing double-ended centring machine. The forging is secured by toggle clamps operated by an air cylinder. High-speed steel centre drills are employed, and the spot-facing tools are tipped with Tantung. The tools are run at 652 r.p.m., and fed at the rate of 0·006 in. per rev.

Centre-drilled and spot-faced forgings are dropped on to conveyors which carry them to stock bins. Next, the stems are turned, and the flanges faced, on Seneca Falls electro-mechanical copying lathes. The operator places the forging on the headstock centre, and locates the lugs on the yoke between dogs on a headstock driver assembly. When the air-operated tailstock is actuated, it pushes the workpiece into the driver, compresses the spring-loaded centre, and locates the forging endwise.

When the operator presses the cycle start-buttons, a spindle-positioning stop is released and a switch is energized to engage the main drive clutch. An air cylinder on the vertical tool-slide moves the two carbide-insert facing tools towards the work at a 6-deg. angle with the vertical. Another air cylinder actuates a clamping mechanism, which locks the facing tool block in the cutting position. The tools are then fed at the rate of 0·011 in. per rev. while a constant cutting speed of 300 ft. per min. is maintained by means of a General Electric variable-speed drive unit. When the facing cuts have been completed, the second air cylinder releases the clamping mechanism, and the first cylinder retracts the block from the work at a 6-deg. angle, so that the tools are clear of the surface. About 0·060 in. of stock is removed by the square carbide insert, which faces the flange, and the triangular carbide insert, which faces the hub.

Contour-turning of the stem and finish-facing of the flange are then performed by means of a diamond-shaped carbide insert tool carried on the front angular tool-slide. Movements of the tool, at a feed rate of 0·022 in. per rev., are controlled by a template mounted on top of the tailstock, as seen in Fig. 1, and a patented Seneca Falls electro-mechanical control system. The system incor-

* Pontiac Motor Division, General Motors Corporation, U.S.A.

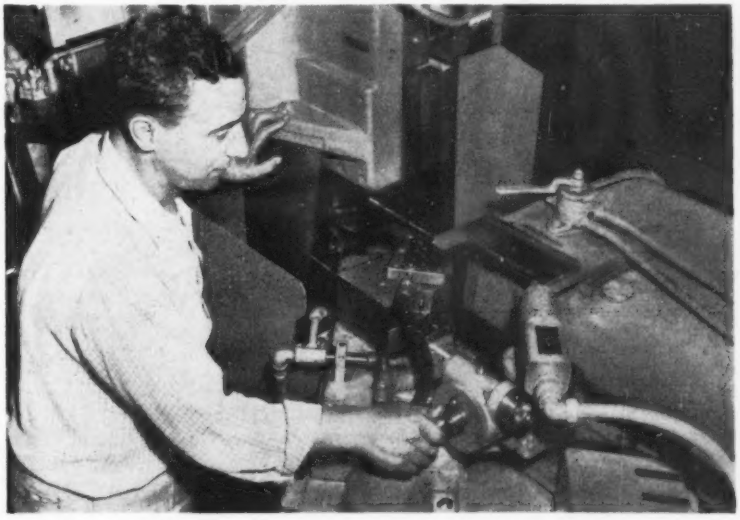


Fig. 1. The Template Seen Mounted on Top of the Lathe Tailstock Controls the Movement of the Contour-turning Tool for Machining the Stub Axle Spindle

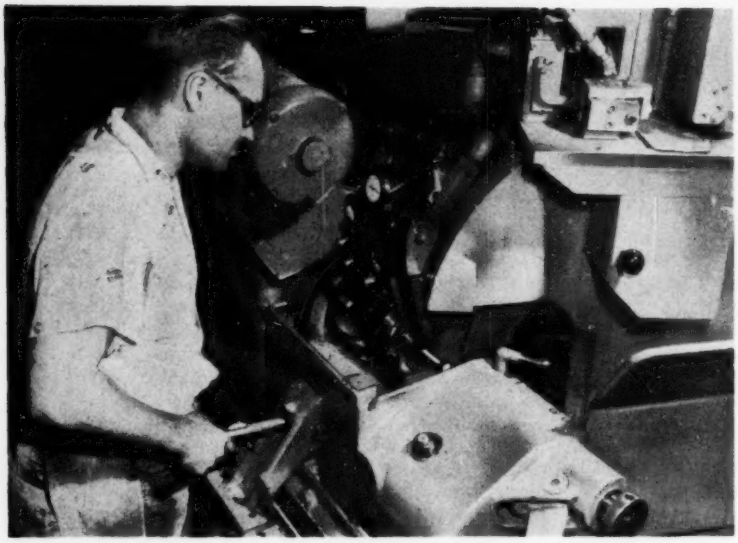


Fig. 2. The Spindle Bearing Surfaces, Oil-seal Contact Surface, and Blending Radii are Finished on this Two-wheel Angular - head Grinding Machine

porates a displacement transducer and template stylus, mounted on a base which is arranged for micrometer adjustment. The transducer has built-in switches for sensing both initial deflection and over-travel of the stylus. An electronic amplifier and a mechanical torque amplifier complete the system. The mechanical amplifier takes its power from a constantly rotating shaft, and moves the tool in accordance with the sensing signal.

From 0·060 to 0·090 in. of stock is removed per side when contour-turning the stub axle stem and about 0·015 in. when finish-facing the flange. After the contour-turning tool has completed its traverse, the clutch on the machine spindle is disengaged, a brake is applied, and a torque motor is energized. This torque motor then takes over the drive (turning the spindle at 26 r.p.m.) and after a short delay, a spindle stop is swung into position. A collar on the spindle contacts a pin on the stop, and thus actuates a switch which de-energizes the torque motor. The spindle is now in the correct position for loading the next part. When the operator retracts the tailstock centre, the machined stub axle is ejected from the driver by the spring-loaded headstock centre.

Forgings are inspected for cracks on a Magna-flux unit, and, after they have been demagnetized, are placed on a conveyor which carries them to power-driven rotary hoppers, of 9-ft. diameter. Operators then load the stub axles between centres on angular wheel-head grinding machines made by the Landis Tool Co. On these machines, one of which is seen in Fig. 2, the two spindle bearing surfaces, the oil-seal contact surface, and three blending radii are finish ground. As indicated in Fig. 3, the two bearing surfaces must be held to a total tolerance of 0·0005 in., and the grinding operation is further complicated by the fact that a compound radius is specified at *X*, between the larger-diameter bearing surface and the oil-seal surface, as shown in the enlarged view.

The wheel-head is set at an angle of 30 deg. and carries two abrasive wheels—one of 27⅛ in.

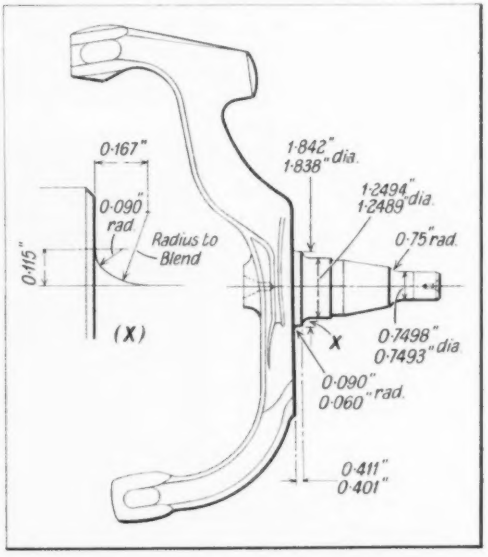


Fig. 3. Surfaces Finished on the Grinding Machine Shown in Fig. 2. The Enlarged View Indicates the Compound Radius Required Between the Bearing and Oil-seal Surfaces

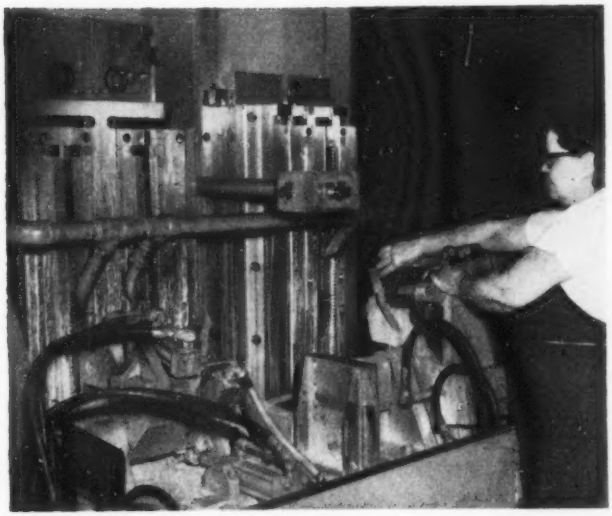


Fig. 4. One of the Dual-ram, 15-ton Machines Employed for Broaching the Upper and Lower Ball-stud Bosses, also the Qualifying Pads on the Stub Axles

diameter by 1¼ in. wide, and the other of 30 in. diameter by 1½ in. wide. Aluminium oxide abrasive of 30 grain size and S grade is employed, and from 0·008 to 0·012 in. of stock is removed in one pass. The machine has a hydraulic straight-infeed motion, and a cam-controlled overhead wheel dresser is traversed hydraulically and is arranged for automatic diamond feed.

Upper ball-stud bosses on the stub axles are finished, lower ball-stud bosses are semi-finished, and qualifying pads are broached, on Colonial 15-ton, 66-in. stroke, dual-ram machines. The bosses on both sides of the ball studs are broached by a total of 346 teeth on the left-hand ram, while the pads are machined with broaches mounted on the right-hand ram, as seen in Fig. 4. The broaching speed is 35 ft. per min. and from 0·060 to 0·090 in. of stock is removed from each surface, about 0·020 in. being left on the lower ball-stud bosses for a subsequent finishing operation on a transfer machine.

Machining of the stub axles is then completed on either of two identical Buhr 16-station transfer machines. On these machines, the stub axles are successively drilled, milled, threaded, reamed, deburred, spot-faced, chamfered, and tapped, as they are indexed from station to station, and production rates up to 221 per hour can be maintained. It may be noted that similar operations performed on a stub axle of earlier design required twelve separate machines, each with an operator.

The workpieces are manually loaded—two into each pallet-type fixture—at the first station. Automatic clamping is effected by means of three Ingersoll-Rand air-motors equipped with stud drivers, which may be seen in the background in Fig. 5. A 2-spindle drill-head is provided on the right-hand side of the machine, at the second station, for drilling a cotter-pin hole of $\frac{5}{32}$-in. diameter through each stub axle spindle. The drills are rotated at 979 r.p.m. (40 surface ft. per min.) and fed at the rate of 0·0031 in per rev.

When the stub axles have been indexed to the third station, seen in Fig. 6, the lower faces of both the upper and lower ball-stud bosses are finish-milled. For this operation, a 2-spindle head on the left-hand side

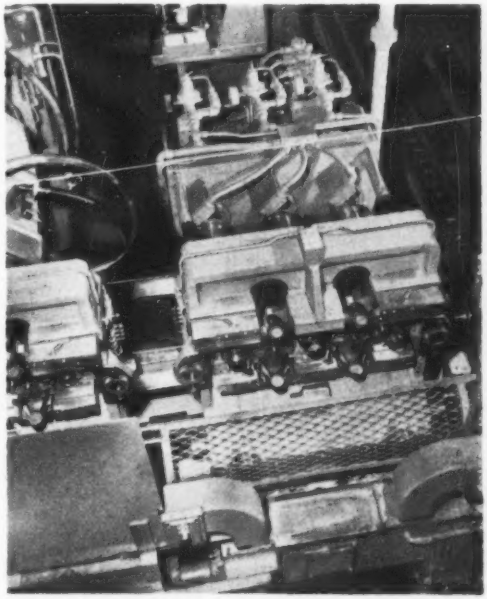


Fig. 5. At the Loading Station of the Transfer Machine, the Stub Axles are Automatically Clamped in a Pallet-type Fixture by Means of Air-motor Type Stud Drivers

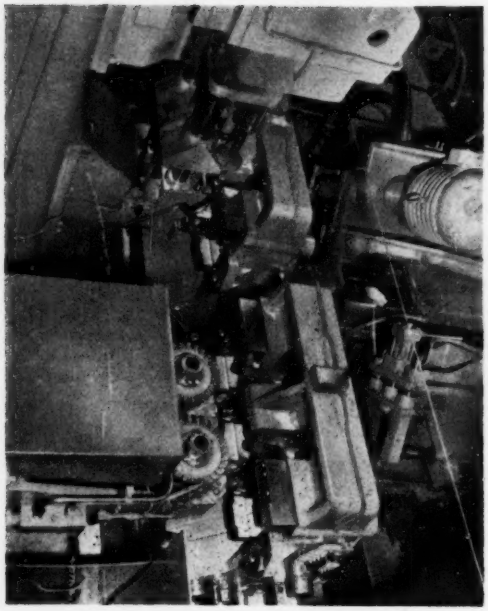


Fig. 6. A View Showing the Third Station (foreground) and Fourth Station (top) of the 16-station Transfer Machine

is equipped with 7½- and 8-in. diameter cutters, each having 26 inserted, tungsten carbide-tipped blades. The cutters are rotated at 102 r.p.m., to provide a cutting speed of about 200 ft. per min., and are fed at the rate of 0·110 in. per rev. Simultaneously, a 2-spindle head mounted on the right-hand side, and equipped with two probes, is advanced to check that the cotter-pin holes were drilled in the parts at the previous operating station.

Holes of $\frac{11}{64}$ in. diameter are drilled through the upper ball-stud bosses, and two more cotter-pin holes of $\frac{5}{32}$ in. diameter are drilled through the stub axle spindles, by tools on the left- and right-hand side heads, respectively, at station 4. The boss-hole drills are run at 398 r.p.m. (54 surface ft. per min.) and are fed at the rate of 0·0078 in. per rev. A right-hand side probe head at the fifth station checks the drilling of the cotter-pin holes.

Jones & Lamson die-heads are mounted on the 2-spindle right-hand side head at station 6, to cut ¾-20 threads on the spindles. For this operation, the die-heads are rotated at 127 r.p.m. (25 surface ft. per min.). The left-hand side head at the sixth station is employed to drill ½-in. diameter holes through the lower ball-stud bosses.

Anchor pin bosses on the right-hand sides of the stub axles are milled at station 7. End mills of 3 in. diameter, with 10 inserted tungsten carbide-tipped blades, are run at 255 r.p.m. and fed at the rate of 0·050 in. per rev. to remove about 0·018 in. of stock from these surfaces. A left-hand side head at the same station is tooled to core-drill ⅝-in. diameter holes through the lower ball-stud bosses. These drills are fed at 0·0178 in. per rev. and rotate at 247 r.p.m. (40 surface ft. per min.).

Station 8 is idle, and was provided to accommodate tooling that may be required if the design of the stub axle is changed in the future. A keyway is milled in the spindle portion of each stub axle by tools on the right-hand side head at

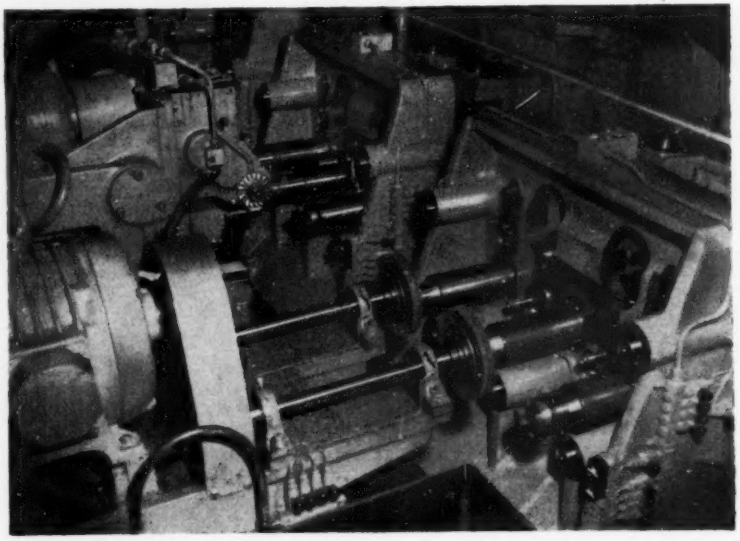


Fig. 7. Wire Brushes on the Right-hand Head at the Tenth Station Serve to Remove Burrs from Threads and Keyways. One of the Keyway Cutters can be seen at the Preceding Station

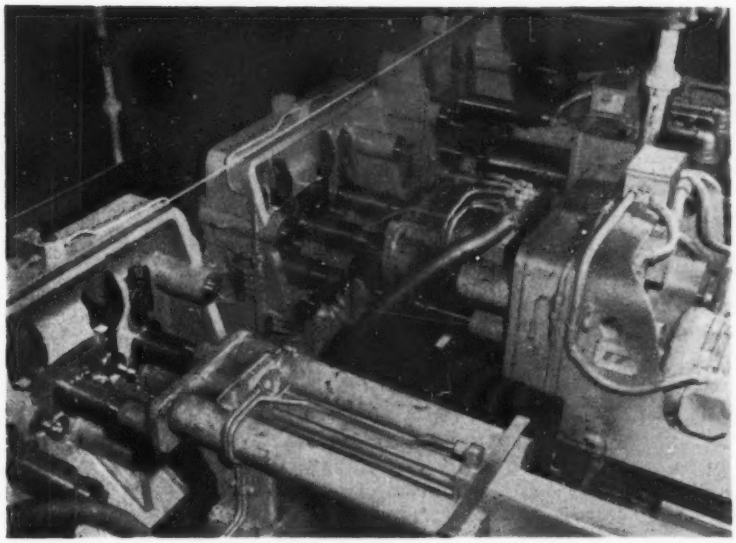


Fig. 8. Anchor Stud Holes in the Stub Axles are Probed and Blown-out at Station 14 (lower left) in Readiness for Tapping at Station 15 (centre)

the ninth station. Both the upper and lower ball-stud holes are rough taper-reamed with tools on the left-hand side head at this station.

Finish taper-reaming of the upper and lower ball-stud holes is carried out at station 10, with the left-hand side head. The right-hand head, seen in Fig. 7, is equipped with two Osborn wire brushes of 6 in. diameter (with 0·008-in. diameter wires encased in rubber), for removing burrs from the threads and keyways. The brushes are rotated at 3,474 r.p.m. in one direction as they are fed towards the work at 18·72 in. per min., and in the opposite direction as they are retracted.

Station 11 is idle, and at station 12 anchor stud holes are drilled to a diameter of 0·5156 in. and a depth of 0·90 in., for subsequent tapping. In addition, two flange holes of 0·460 in. diameter are drilled in each component. The anchor stud holes and the two flange holes in each stub axle are chamfered, and two bosses are spot-faced, by tooling on the right- and left-hand side heads at station 13. Combination spot-facing and chamfering tools, each with six tungsten carbide teeth, are used for this operation. These tools are rotated at 230 r.p.m. (120 surface ft. per min.) and are fed at the rate of 0·008 in. per rev.

At the 14th station, seen at the lower left in Fig. 8, the anchor stud holes are probed and blown-out in readiness for tapping at station 15 (seen in the centre of the illustration). The taps are run at a speed of 170 r.p.m. (25 surface ft. per min.). Tungsten carbide-tipped step reamers are also mounted on the right-hand side head at

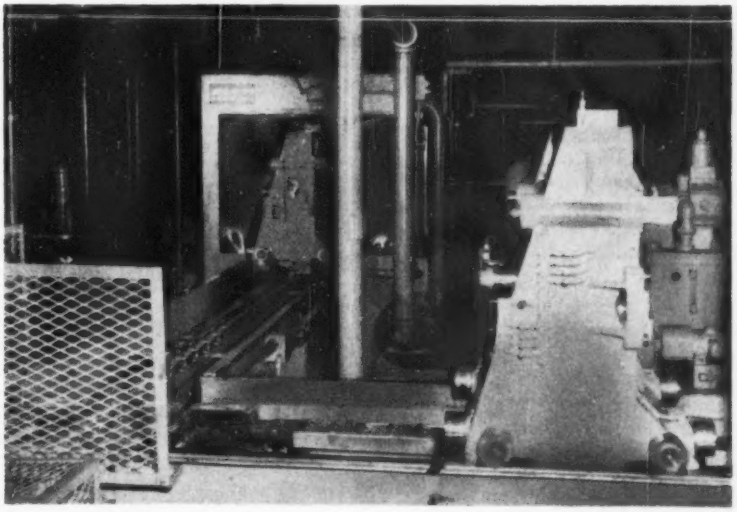


Fig. 9. Empty Pallet-type Fixtures are Shuttled to a Chain Conveyor which Carries them through a Washing Machine and Returns them to the Loading Station

this station, for reaming the two flange holes in each part to a diameter of 0·460 in.

Ingersoll-Rand reversible air-motors with stud drivers are provided on the right-hand side head at station 16 for automatically unclamping the completed workpieces. On the left-hand side of the machine at this position, a Pontiac-designed automatic unloading unit is provided. This air-operated, limit switch-controlled unit incorporates work-supporting centres on reciprocating arms. When the arms have been advanced to the pallet-type fixture, the centres are fed outwards to enter the ball-stud holes. The stub axles are then withdrawn from the fixture, and are turned through 90 deg., before they are dropped on to a conveyor.

A total of 21 pallets is provided on each transfer machine. An automatic lubrication unit supplies oil to the bearing surfaces as every tenth pallet passes it. Unloaded pallets are automatically shuttled, at right angles to the direction in which they have been transferred, on to a parallel chain conveyor, seen in Fig. 9. This conveyor carries them through a washer and returns them to the loading end of the transfer machine.

After they have been washed, the stub axles are subjected to a final inspection, and those which are acceptable are sent forward to the final assembly line.

Modification of Crank-driven Motion by Cam

By W. M. FOSTER

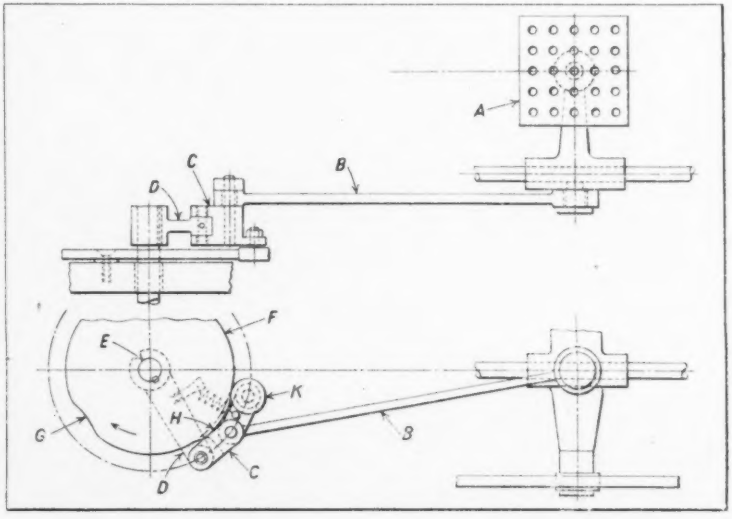
In a certain manufacturing process, sheets arriving on one conveyor section are transferred to another section by means of a suction plate. This plate is crank-driven through a connecting-rod and has a straight-line movement between the ends of the sections. Sheets arrive at regular intervals, and it is essential that the movement of the suction plate should be approximately uniform while each sheet is being picked up, transferred, and deposited.

The periods during which uniform movement was required corresponded to 10 deg. of crank rotation for picking up, and another 10 deg. when depositing.

To achieve this result a cam is employed as seen in the accompanying illustration. The suction plate *A* is connected to the crank *D* by the connecting-rod *B* and link *C*. The crank is keyed to the drive-shaft *E* which rotates at a constant speed, and the compensating cam *F*, with a drop *G* and a rise *H*, is fixed by countersunk screws to the frame of the mechanism.

At one end, the link *C* carries a roll *K* which is spring-loaded against the periphery of the cam. The drive-shaft rotates clockwise, and when the roll contacts the drop on the cam, the effective length of the crank is decreased, so that the velocity of the suction plate is reduced. Conversely, the velocity of the suction plate is increased when the roll *K* makes contact with the rise of the cam.

The drop and rise areas are so located as to produce the near-uniform velocity at the desired points in the cycle of the suction plate.



The Effect of the Compensating Cam *F* is to Provide Nearly Uniform Velocity of the Plate *A* at Two Stages During the Cycle

Die Casting Supplement

The Establishment of Dimensional Norms For Die Castings

By H. K. BARTON

Although die casting as a process—the injection of molten metal into a rigid die—is now more than a century old, die casting as an industry is largely a development of the last twenty years. Before the second world war, it was possible to encounter competent production engineers who were somewhat uncertain as to what a die casting actually was, and who had no knowledge at all of the alloys used or of the qualities to be expected of a die cast product. Today, when there are few engineering products of any complexity that do not incorporate at least one or two die cast components, the nature of the process is well understood, and its advantages and limitations generally appreciated. The qualities to be expected of a die cast product are, however, still almost as much a matter for debate between the die caster and customer as they were 20 years ago.

To a great extent, this situation is the result of the structure and growth pattern of the die casting industry, neither of which have, until very recently, been such as to permit any appreciable standardization of die casting quality. Standards are easiest to impose, and are most readily accepted, in monolithic industries with restricted ranges of products. The possession of fundamental patents, for example, has often made it possible for a single organization to monopolize manufacture of a particular range of products for a period of years. Even when such a monopoly has ended, competitors entering the field have found it necessary to accept the quality standards already in being, without respect to their merits.

In die casting, no such conditions have prevailed. Even the largest producers have developed from relatively small beginnings, and there can be few processes less hampered by patents. Moreover, the entry of companies into the field of die casting has come about from very diverse considerations, and the preconceptions as to what constitutes acceptable casting quality have varied accordingly. Some die casting plants were first installed as appendages to sand casting foundries, whereas others began as adjuncts to a machine shop, or grew, by diversification of products, out of some specialized department concerned—for example—with the casting of white-metal bearings.

Because of this disparity of origins, the establishment of a norm for product quality would have been a very slow process, even had the range of products been restricted. In fact, however, the versatility of the process has led to the continual widening of the field within which die cast components are used, and, in consequence, to an ever-increasing diversity of functional requirements. As techniques and equipment have improved, die casters have produced larger and sounder castings, smaller and more precise castings, and castings of eggshell thinness and superfine finish.

THE TENDENCY TO "OVER-SPECIFY"

Of late years, therefore, it has seemed—and to a large extent has been true—that the die casting process can meet virtually any standards of surface quality, density, thinness of section, and dimensional accuracy. Quite naturally, it is the more technically advanced products of the process that receive the most attention and are featured most prominently in promotional literature. Certainly, it is all to the good that prospective customers should be kept informed of advances in scope and technique, but there is no doubt that many of the less well-informed buyers are inclined, on the basis of the many advertised excellences of the die casting process, to "over-specify." Although

the component in which they are interested may be intended to replace a grey iron sand casting that they were previously content to use unmachined, apart from the free-hand drilling of two or three holes, they require the substituted die casting to have the surface finish of a headlamp reflector, the dimensional accuracy of an adding-machine frame, and the internal soundness of an hydraulic pump body. The more sanguine are likely, in addition, to ask for the parts to be cast in an alloy combining the ductility of zinc with the lightness of aluminium, and nearly all will be quite sure that the die castings will be much cheaper than the raw sand castings that they replace.

This problem—what the lay buyer ought to expect of the die cast components that he is thinking of buying—became of real importance to the die casting industry of the United States some seven or eight years ago, when it was already evident that a great many buyers were inclined to over-specify. The American Die Casting Institute, representative of the leading contract producers of die castings, accordingly embarked upon the compilation of a series of "Product Standards" which should serve as norms for the production of die cast parts in the four main alloy groups.

Over-specification may take the form of insistance upon an unnecessarily high standard of surface finish, having regard to the nature and functions of the product (as frequently happens in this country), of establishing the minimum casting weight at a figure approaching that of wrought metal, or of demanding high values for mechanical properties at locations on the casting where they are unessential. Most frequently, however, over-specification takes the form of a request for closer limits than are really required.

This practice, indeed, is very widespread, and results in buyers of die castings having to pay more for them than would be necessary if more liberal specifications were put forward. Every die caster has ample evidence that in very many instances the close limits insisted upon by his customers bear no relation at all to actual requirements. This fact is quite frequently made obvious because, once samples to the specified close limits have been checked and approved, the customer remains oblivious to relatively large dimensional changes resulting from core replacement, wear of registers, or damage to cavities.

It is a common experience, for example, that a customer insists upon some cored hole in a component being held to limits of ±0·001 in., so that the draft on the core is quite inadequate, and rejects samples that are few "tenths" outside the limits. Once the tool is in production, however, draft on the cores often has to be increased in order to permit easy ejection. In such an instance, the die caster is prepared to clear the holes to size should the customer query the modification, but in a surprising number of instances the change passes quite unnoticed.

THE FUNCTION OF PRODUCT STANDARDS

The purpose of the A.D.C.I. Product Standards was to persuade designers and buyers to think in terms of normal rather than extreme values, so that they will demand of a die casting the minimal qualities necessary for it to perform its designated function, rather than insist on the highest standards of which the process is capable. In the introduction to the "E" series (Engineering) standards it is pointed out that, although die castings can be produced which are excellent as regards surface finish and dimensional precision, and have minimum draft, all the requirements in maximum degree combined in one die casting are seldom, if ever, required. For this reason, the standards cover values consistent with speedy, uninterrupted production, reasonable die and tool life and maintenance cost, normal inspection, packing and transport costs. Conformity to these standards ensures dependable service and minimum cost, but special requirements for finish, accuracy and other characteristics, beyond the limits of the standards, can usually be met at a small extra expense.

The first of the Product Standards, covering linear tolerances, draft, flatness and some other factors affecting product dimensions were issued some two years ago, and within a few months were being used by many buyers of die castings as a basis for specifications. It is likely that this rapid acceptance came about not specifically because the actual values incorporated in the standards met every need, but largely because it is far easier to specify, for example, "flatness to be within the limit of A.D.C.I.-E5-55T" than to determine exactly what departure from flatness can be tolerated in a particular component.

Moreover, the mere fact that a die casting is to be produced to a published standard, rather than to a set of *ad hoc* limits, is calculated to instil confidence. It is in fact already clear that buyers who would, in the past, have resisted any attempt to persuade them to accept larger linear tolerances because they felt obscurely that this would have meant that a lower quality product was being foisted upon them, will today agree to the wider ADCI tolerances because these are presented as "standard to the trade."

Standards—and particularly those covering dimensional precision—are thus seen to be of real value even without direct regard to the level at

which a particular characteristic is standardized. Indeed, since the degree of accuracy required in a die cast component, as often as not, is established arbitrarily, the mere existence of a standard that can serve as a reference for buyer and die caster alike is a sufficient reason for its general adoption. The level at which a specific factor is to be standardized is a matter of less concern to the users of die castings than to the die casters themselves, since the adoption of *any* standard value for dimensional accuracy clearly imposes at least a minimum obligation upon the die casting trade at large.

From the die caster's point of view, the wider the limits that are adopted in the standard, the easier is production of the castings. On the other hand, the establishment of too low a norm might well result, in the long run, in the dimensional accuracy of die casting being made to appear less favourable than those associated in the customer's mind with competitive processes. These considerations must always bulk larger than such factors as "the inherent accuracy of the process" in determining standardization levels.

There is, in fact, no upper limit of accuracy. Provided that the control of casting temperature and other factors is sufficiently close, and that no arbitrary upper limit is set to the percentage of rejects, any required degree of dimensional precision can be held. What is always at issue is the degree of precision for which the customer will find it worthwhile to pay. In the nature of things, few customers have a sufficient knowledge of the die casting process to be able to determine this for themselves, so that in establishing a standard, the die caster is saying in effect "this is the level of accuracy that, under the conditions now envisaged, offers the most efficient compromise between low cost and high precision."

FACTORS AFFECTING DIMENSIONAL ACCURACY

The establishment of levels of dimensional accuracy for die cast components is necessarily a rather arbitrary procedure, since the extent of the control that can be maintained upon critical dimensions varies very greatly (the actual dimensions being, of course, assumed to be nominally identical) between one component and another of different form. Overall speed of operation, the length of the casting cycle, and even the proportion of the whole cycle allotted to the solidification dwell, can all affect the degree of dimensional consistency that is obtained during a production run. Indeed, two operators, operating the same die and machine on alternate shifts, can produce castings for which the means of the longer dimensions differ appreciably, due to the tempo of one being more erratic than that of the other. Clearly, the closest limits that can be adopted in practice must allow for variations of this nature.

Actually, linear tolerances must take account of several possible sources of variation, some of which tend to cancel each other out. The net effect of all of them is often termed "cooling contraction," but contraction of the casting itself is, in fact, only one of the causes of dimensional variation. In the first place, it is necessary to remember that dimensional inconsistency—or consistency—is quite distinct from dimensional accuracy. A component may have a critical dimension which, in practice, is held to a constant value within ±0·002 in. when the specification only demands limits of ±0·005 in. If, however, the actual dimensions vary about a mean which differs by 0·006 in. from the nominal dimension, as in Fig. 1, a large proportion of the components will be rejects, despite the consistency with which they are being produced.

The limits adopted, therefore, must allow for (1) variations from drawing dimensions in the cold die cavity; (2) changes in cavity dimensions when the tool is raised to casting temperature; (3) variations in the cavity dimensions corresponding to fluctuations in die temperature; (4) the extent to which free contraction is inhibited by the form of the cavity during the phase of the casting cycle between solidification and ejection, and (5) the

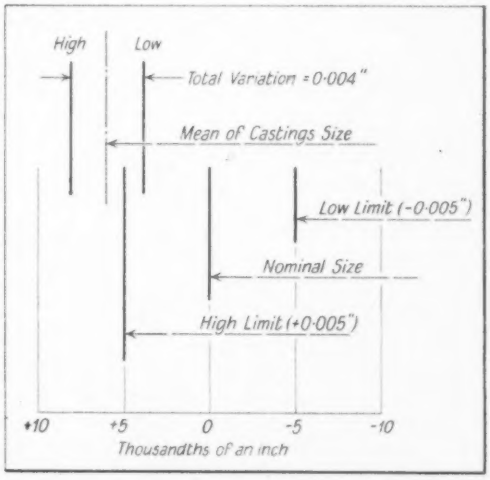


Fig. 1. Although Consistent to Within ± 0·002 in., Castings May be Largely Unacceptable Because They are Outside the Specified Limits of ± 0·005 in. on the Nominal Dimension

temperature at which the component is ejected from the die. Apart from (1) and (4), the effects of all these factors can be calculated for various combinations of casting conditions. Since the actual optimum casting conditions can only be determined after the die has been completed, however, such calculations are of no assistance in determining what initial cavity dimension will produce a specific dimension on the component, nor the extent to which the latter will be subject to variation as a result of unavoidable fluctuations in the cycle. Because of this uncertainty, when formulating any standard for linear tolerances, arbitrary maximum values must be assumed for errors of die-sinking and for both constrained and free contraction.

Assessment of these values is not a very easy matter, particularly for a committee of practising die casters, since, to some extent, the magnitudes of such errors are criteria of technical competence. Levels of accuracy—in die-sinking and in production—that are maintained without difficulty in one plant may be achieved only by special effort by a company less experienced or equipped with less modern plant. Moreover, the quality of a company's die castings depends to a surprising extent upon the complaisance or otherwise of its customers. Die casters producing parts mainly for discriminating markets—such as car furniture, and camera and instrument components—are likely to maintain higher quality standards in every respect than do jobbing casters who are concerned mainly with products of such a nature that surface finish and/or dimensional accuracy are less important, for example, loom parts, switchgear components, and coffin furniture. In small tied plants, moreover, there is often a deterioration of standards, whereas the larger tied die casting foundries are usually kept up to the mark by the practice—quite general among parent companies—of buying a proportion of requirements from contract producers.

The establishment of quality norms for incorporation in a set of standards which is to be of real value must therefore act as an incentive to those producers who are inclined to "underfulfil," as well as a deterrent to those buyers addicted to over-specifying. The norms adopted, in other words, must be those of a reasonably competent producer. Moreover, standards for dimensional tolerances intended to be used by buyers of die castings in general should preferably be kept few and simple. The tolerance on a dimension taken between a fixed point in the die, and a point on a moving element such as a core, must necessarily be greater than the tolerance on an equivalent dimension between two fixed points. In practice, the required margin differs somewhat according to the disposition and orientation of the moving die element, but this fact only assumes importance when particularly critical dimensions are involved. At a less exacting level, it suffices to specify tolerances broad enough to cover all dimensions involving moving die elements.

This course, however, leads to difficulties because errors due to die displacements are substantially independent of the magnitude of the dimensions. If tolerances are increased in proportion to length,

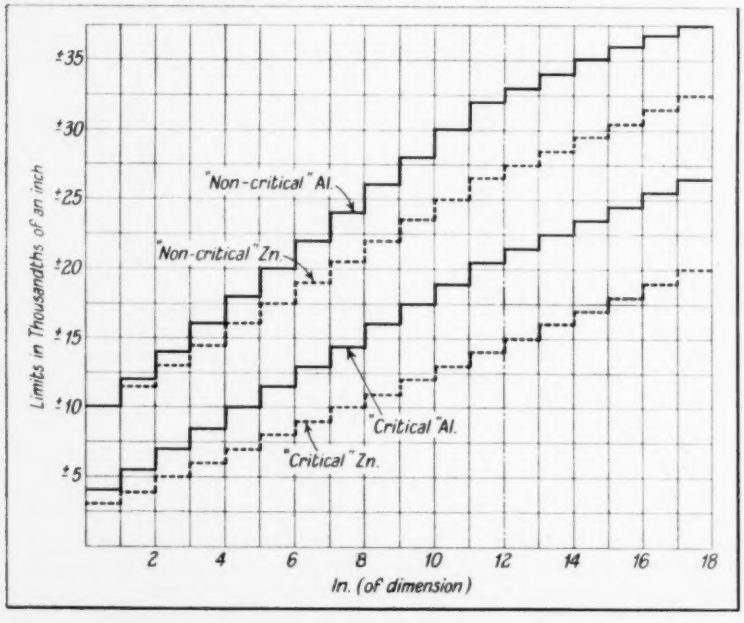


Fig. 2. Tolerance Ranges for "Critical" and "Non-critical" Dimensions in the A.D.C.I. Standard

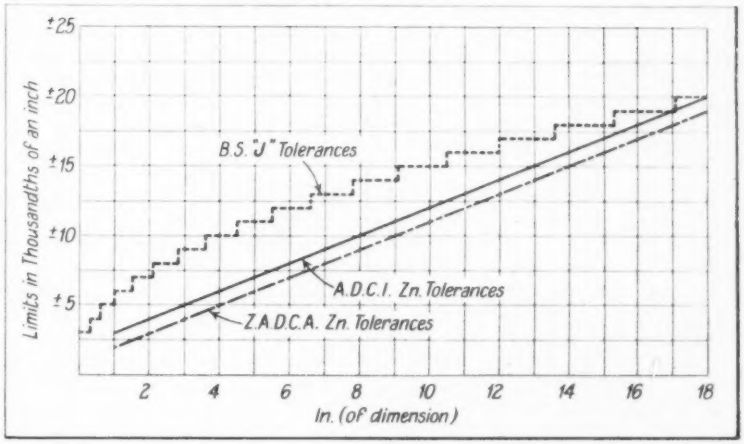


Fig. 3. Tolerances for Zinc Alloys in the U.S. and U.K. Standards are Here Compared with B.S. "J" Tolerances

they quickly become unacceptably large, and it is therefore necessary to provide a basic tolerance independent of the magnitude of the dimension involved, and to add a smaller amount which increases with the length of the dimension. Even this procedure quickly leads to unacceptable limits, so that it is desirable to reduce the value of the increments for dimensions in excess of 12 or 18 in. There is, indeed, some operational justification for such adjustments. Dimensional variation per inch tends to be somewhat greater for the middle range of castings than for either very small or very large parts. Small components are normally produced at a steady, fast rate, and large castings at an equally steady, but slow rate. At both extremes of the range, therefore, the thermal variations in core and cavity dimensions are smaller.

A.D.C.I. LINEAR TOLERANCES

The linear tolerances of the A.D.C.I. Product Standards were determined in the manner outlined above, and two distinct tolerance ranges have been developed. These ranges refer to "critical" dimensions—3-place decimal dimensions—and "non-critical" or fractional dimensions, and are plotted for both zinc and the light alloys (the tolerances for aluminium and magnesium are identical) in Fig. 2. The basic limits for zinc alloys—for dimensions below 1 in.—are ±0·003 in., and for each additional inch a further margin of ±0·001 in. is added. Thus, for a dimension of 8 in., the limits are ±0·010 in., and for an 18-in. "critical" dimension the limits are ±0·020 in.

The limits for non-critical dimensions in zinc begin at ±0·010 in. for dimensions up to 1 in., and for a 12-in. dimension they are ±0·0265 in., and for an 18-in. dimension, ±0·0325 in. The corresponding values for the light alloys increase somewhat more rapidly in both ranges up to a length of 12 in., after which the increment in each instance is ±0·001 in. per inch.

Z.A.D.C.A. LINEAR TOLERANCES

During the past two years the A.D.C.I. linear tolerances (other product standards have been compiled, but the linear tolerances are fundamental) have proved of appreciable value in reducing "over-specifying," and although, in the writer's view, this result has been little influenced by the actual tolerance levels that have been standardized, it is satisfactory to learn that the Zinc Alloy Die Casters Association (in collaboration with A.D.C.I. itself and our own B.I.M.F.A.) has developed and published a parallel set of standards for the guidance of British designers and buyers. These "Engineering Standards for Pressure Die Casting" are contained in a well-produced large quarto booklet (obtainable on application to the Association, 34 Berkeley Square, London, W.1).

For the most part, the values adopted are substantially identical with those of the corresponding A.D.C.I. Product Standards, but the basic tolerances are smaller for both zinc and light alloys. Since the increments are the same in both the A.D.C.I. and the Z.A.D.C.A. specifications, the tolerances on any given dimension are smaller in the latter. This statement applies to dimensions of every magnitude for zinc alloys, and to dimensions up to 12 in. for light alloys. On larger dimensions the Z.A.D.C.A. tolerances increase more rapidly than do the A.D.C.I. tolerances, since there is no similar reduction in the increment at 12 in. The precise relationship, for zinc alloys, is shown in Fig. 3, the step-like progression being here replaced, for clarity, by the equivalent straight lines.

British die casters thus offer, as normal, a slightly higher degree of dimensional accuracy than is laid down in the American standards. At the

same time, it must be noted that even the tolerances on "critical" dimensions are large, compared with any of the usual tolerance levels for machined parts. The only comparable range, indeed, is the British Standard "J" series—"Holes and Shafts for Non-mating Fits"—for which the relevant values are indicated by dotted line in Fig. 3.

It is clear, therefore, that in neither the British nor the U.S. specifications is there any real justification for using the terms "critical" and "non-critical." For dimensions of any magnitude above 1 in., the specified tolerances, in every case, are quite definitely applicable only to non-critical dimensions, for example, for non-mating fits, or for parts that do not have to be assembled with others. This situation, indeed, is as it should be. The standards are intended to apply to *normal* dimensions, and, normally, dimensions on die castings are not critical. It may well happen that for a component with 40 or 50 determinable dimensions, only a half-dozen or so are of "critical" character. Moreover, some of these critical dimensions may relate to features produced in secondary operations—such as holes that are drilled rather than cored.

The point at issue is not whether the tolerance levels have been appropriately chosen (experience in the U.S.A. since 1955 shows that they are perfectly adequate for most dimensions on most die castings), but only whether they are appropriately named. By applying the term "critical" to dimensions that, when they carry their appropriate tolerances according to the standards, do not provide a basis for any sort of engineering fit, the impression is given that die casters work to standards that are lower than normal engineering standards, and this is not true. As those conversant with the trade well know, the skill and precision that go into the construction of the normal die casting die are of the very highest order, and anything that conveys a contrary impression to the mind of the lay buyer is to be deprecated.

One is inclined to conclude, therefore, that it would have been better, on all counts, to have made it clear that both ranges are, from the general engineering viewpoint, non-critical, and to have termed them tolerances for "non-critical dimensions given to three decimal places," and for "non-critical dimensions given to two decimal places or as fractions," with the proviso that the tolerances to be held on really critical dimensions are a matter to be discussed with the die caster, or taken up with the Technical Committee of Z.A.D.C.A.

In practice, indeed, this course must be followed: designers thinking of specifying closer limits than the tolerance levels permit are required to discuss them specifically with their die casting suppliers, and this stipulation is in no way affected by whether the dimensions in question are termed "critical" or "non-critical" by the die caster. It is in the interest of all concerned, therefore, that the term "critical dimension" should be applied in its usual and established sense as implying that the dimension in question stands in some specific relationship—for example to control a fit, a clearance, or an alignment—with another dimension, within normal engineering limits.

PRECISION OBTAINABLE

In presenting the new Engineering Standards, Z.A.D.C.A. did indeed take pains to emphasize the difference between the degree of precision recommended and the finest that can be normally achieved. It was stated, for instance, that for a linear dimension on a zinc alloy die casting to B.S. 1004—the dimension being given to three decimal places and not relating to a measurement across the die parting, nor involving a moving die element—whereas the first Standard shows limits of ±0·002-in. for the first inch, with ±0·001-in. for each additional inch, if necessary, a minimum variation of 0·001 in. per inch (limits of ±0·0005 in. per inch) can be maintained.

In this context, "the finest (degree of precision) that can normally be achieved" may be taken as implying "the finest degree of precision that is normally worth paying for." The suggested tolerance level confirms this impression. Although it represents a much higher degree of accuracy than is provided by the tolerances of the present Standards, it still falls short of the ultimate precision achievable with ordinary commercial machines, as exemplified, for example, in the series of linear dimensional tolerances developed by G. Loewy. These tolerances, to all intents, represent the technical limitations upon the dimensional consistency of die cast parts. It is useless to specify as-cast dimensions to closer tolerances than those laid down by Loewy, however critical the dimensions may be, unless the parts in question are to be produced on a laboratory die casting machine instead of in a foundry.

This point need not be pursued further as in MACHINERY (87/1533-30/12/55) was published a quite extensive survey by E. Newman Field of the precise relationships between the tolerance ranges of the then recently-issued A.D.C.I. Product Standards, the Loewy tolerances, and the 1949 revision of the present writer's "commercial" tolerances, which were avowedly intended to represent the finest precision normally worth paying for. The three systems have different purposes in view, and

there is a use for each. In the light of comments made from time to time by contract die-makers, it seems that there is need for a further survey to determine the limits to which the die-sinker must work, if each of the tolerance ranges is to be achieved with normal fluctuation of operating conditions.

DIMENSIONS ACROSS THE PARTING LINE

The linear tolerances so far discussed are the most fundamental factor in assessing the potential accuracy of die castings, but brief comments may perhaps be made on some of the others. Standard 2—Additional Parting Line Tolerance Based on Single Cavity Die—relates to dimensions taken across the die parting. The tolerances, which are to be added to the appropriate linear tolerances based on the magnitudes of the dimensions in question, are correlated with casting area, since the larger the projected area of the component, the heavier the peripheral flash.

The purpose of this standard is rather different from that of the linear tolerance standard. Whereas the latter serves to define limits within which the actual casting dimensions are likely to vary in a random manner, the die parting tolerance is largely intended to ensure that a relatively small proportion of castings produced with a heavy flash, but otherwise dimensionally satisfactory, will not be rejected. The tolerances suggested are bilateral, which allows for grinding up the die face if the nominal dimension is originally held by the tool-maker.

As shown in Table 1, the values proposed range from ±0·003 in. for castings having a projected area up to 25 sq. in., to ±0·012 in. where the area is between 200 and 300 sq. in. This latter value raises some doubts, because although, as a rule, dimensions taken from a point inside a casting to a point outside are not critical—and if they are, can be easily brought within the required limits by facing off bosses or similar simple operations—a weight limit might very well impose dimensional limits well within those suggested by this standard.

TABLE 1. ADDITIONAL PARTING LINE TOLERANCES IN INCHES

Projected Area of Die Casting	Die Casting Alloy		
	Zinc	Aluminium	Magnesium
Up to 25 sq. in.	±0·003	±0·004	±0·004
25-50 sq. in.....	±0·004	±0·005	±0·005
50-100 sq. in.	±0·006	±0·008	±0·008
100-200 sq. in.....	±0·008	±0·012	±0·012
200-300 sq. in.....	±0·012	±0·015	±0·015

Additional tolerances in the case of moving die parts are shown in Table 2.

TABLE 2. ADDITIONAL MOVING DIE PART TOLERANCES IN INCHES

Projected Area of Portion of Die Casting	Die Casting Alloy		
	Zinc	Aluminium	Magnesium
Up to 10 sq. in.	±0·004	±0·005	±0·005
10-20 sq. in.....	±0·006	±0·008	±0·008
20-50 sq. in.....	±0·008	±0·012	±0·012
50-100 sq. in.	±0·012	±0·015	±0·015

A 300 sq. in. zinc casting, with a mean thickness of 0·120-in., weighs about 140 oz. The tolerance level here suggested represents a minimum weight of about 126 oz. and a maximum of 154 oz., or a total weight variation, on a 9-lb. (nominal) casting, of 1¾ lb. It is clear, therefore, that this standard is intended to cover not merely the normal random variations in flash thickness, but also the occasional exceptionally heavy flash that results from particles of metal debris lodging on the die face.

It is not easy to be convinced that such an all-embracing conception of die-parting tolerance was justified. The standard implies, for example, that a 0·750-in. (nominal) deep boss in a 20-in. by 15-in. die casting should be dimensioned 0·764/0·736 in. if it is "critical." Should it be non-critical, the buyer could expect measurements somewhere between 0·772-in. and 0·728-in.—a total possible variation of 0·044-in. In practice, of course, no such variation between two castings of a batch could conceivably occur, but the lay buyer conscientiously studying the standards can only accept what they purport to convey.

DIMENSIONS CONTROLLED BY MOVING CORE BLOCKS

In Standard 3, which relates to dimensions partly controlled by moving core-blocks, the limits range from a minimum of ±0·004-in. to a maximum of ±0·012-in., as shown in Table 2. Here, however, the wide limits are justified, since there are many sources of dimensional variation in the possible displacements of massive cores like that shown in Fig. 4. Wear on the sliding elements and locking surfaces can easily result in the core being forced back slightly by the metal pressure, and, however well the slide is fitted, flakes of metal and lubricant residues progressively build up within a core hous-

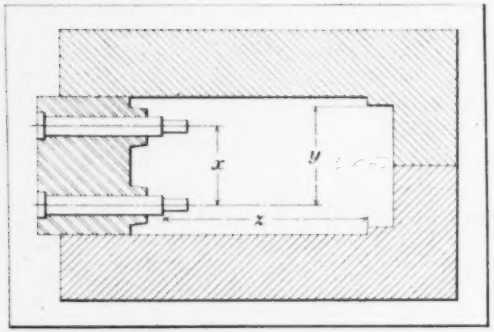


Fig. 4. Dimensions such as *X* can be Held to Close Limits, but *Y* and *Z* Depend on Moving Die Elements and Demand Much Wider Tolerances

ing and cause variations in all dimensions taken from the core surface. It is not possible to correct these minor changes at frequent intervals, since it would often be necessary to strip down the die for this purpose, so that the tolerances must allow for fairly large cumulative displacements before servicing is carried out.

STANDARDS FOR DRAFT ANGLES

Standard 4 covers the draft requirements on surfaces normal to the die parting, and is admirable in all respects. Taper angles appropriate for the three main alloy groups are shown on log-log graph paper by straight lines. Thus, for zinc alloys, the preferred taper on an inside wall varies from 10 deg. on a wall 0·013 in. deep to ½ deg. on a 6-in. wall, the corresponding drafts in inches being 0·0022 in. and 0·045 in., respectively. For outside walls, the required values are 50 per cent of those for inside walls of the same height. The presentation of this graph in the Z.A.D.C.A. publication, where it occupies the centre spread, is much superior to that of the equivalent A.D.C.I. standard, in which the same material is split between two separate sheets.

FLATNESS TOLERANCES

The flatness tolerance of Standard 5 allows for a reasonable—from the die caster's viewpoint—degree of distortion at ejection or during cooling. Here again, the standard represents not so much a norm—since castings are not normally distorted—but rather a cover for distortions that happen occasionally during normal production. Thus, on an 18-in. length, the permissible variation is $15 \times 0{\cdot}003$ in., $+0{\cdot}008$ in., or a total of 0·053-in. Distortions of this magnitude are very rare, and it is quite practicable, for example, to die cast the bodies of long spirit-levels (Fig. 5) in light alloy, with the assurance that only the minimum grinding will be needed to bring the lower face to acceptable flatness.

DEPTH AND TAPER OF HOLES

Standard 6, for "Depth and Taper of Cored Holes," summarizes in tabular form the maximum depths and required tapers on cored holes, and follows closely the proportions that have of late years proved generally satisfactory. These values are reproduced in Table 3, and relate to holes that are not required to be tapped. The standard does, however, include specific suggestions for determining coring sizes for tapping holes.

EJECTOR PIN MARKS

Ejector pin marks, which so often lead to acrimonious exchanges between die caster and customer, are the subject of Standard 7. It is recommended that the range of acceptability shall extend from a depression of 0·015 in. below the

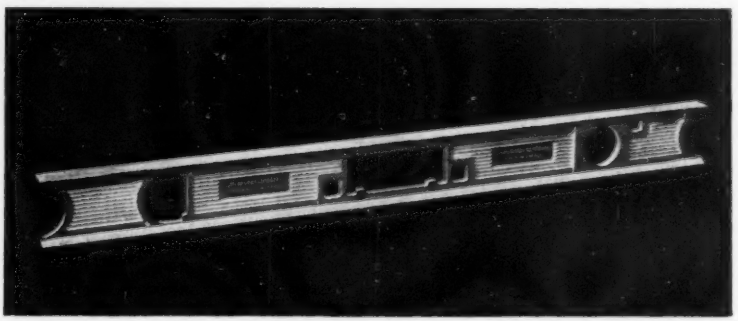


Fig. 5. An Indication of the Flatness Obtainable is Afforded by the Fact that an Aluminium Die Casting is Employed for the Frame of this Spirit Level made by Gjuteriaktiebolaget Fundator, Stockholm

casting surface, to a projection from the surface of the same amount, as indicated at *a* in Fig. 6. The values of ±0·015-in., although of course quite arbitrary, are reasonable. Here, however, it might have been desirable to provide for a "critical" tolerance with a range from, say, 0·002 in. depression to 0·022 in. depression as shown at *b* in Fig. 6, in addition to that specified. Most buyers prefer ejector marks to be a little below the surface. Indeed it is not of much importance—except for the very thinnest castings—whether the depth to which the ejector mark is depressed is 0·015 in. or more. From the die caster's point of view, however, it is better if the ejector marks stand a little proud, as removal of the casting from the ejectors is then somewhat easier. The advantage, at best, is slight, and when the tool has been in use for some time a cap of flash is formed around the ejector tip in either case, as seen at *c*, and there is then little to choose, operationally, between the two dispositions.

TABLE 3. DEPTH AND TAPER OF CORED HOLES

Alloy			Diameter of Hole (in.)								
			⅛	5/32	7/32	¼	⅜	½	⅝	¾	1 and over
Zinc	Depth, in.		⅜	7/16	½	1	1½	2	3½	4½	6
	Taper on dia.	Deg.	2⅝	2¼	2	1⅝	1½	1⅛	1	¾	½
		In.	inc. 0·018	inc. 0·022	inc. 0·026	inc. 0·030	inc. 0·039	inc. 0·047	inc. 0·054	inc. 0·065	inc. 0·079
Aluminium	Depth, in.		7/16	½	⅝	1	1½	2	3½	4½	6
	Taper on dia.	Deg.	5	4	3⅜	3	2¼	2	1⅝	1⅛	1
		In.	inc. 0·028	inc. 0·035	inc. 0·039	inc. 0·052	inc. 0·062	inc. 0·070	inc. 0·090	inc. 0·105	inc. 0·105
Magnesium	Depth, in.		7/16	½	⅝	1	1½	2	3½	4½	6
	Taper on dia.	Deg.	4½	3½	3	2½	2	1⅝	1½	1⅛	1
		In.	inc. 0·023	inc. 0·030	inc. 0·033	inc. 0·044	inc. 0·052	inc. 0·058	inc. 0·082	inc. 0·105	inc. 0·105

Note 1. The depths and tapers shown are not applicable under conditions where small diameter cores are widely spaced and, by design, are subject to full shrinkage stress.
Note 2. Holes to be tapped have different taper and depth requirements from those shown above.

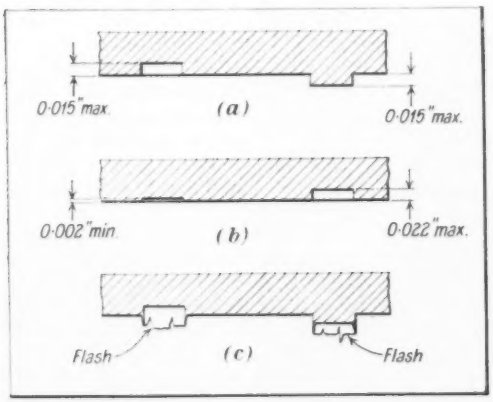


Fig. 6. Ejector Marks May be Either Raised or Recessed as at *a* Under the Standard. The Writer Suggests the Provision of an Alternative "Critical" Standard with All Marks Sunk as at *b*. In Operation, Tool Wear Soon Results in the Formation of a Capping of Flash Around Both Sunk and Raised Ejector Marks, as Indicated at *c*

MACHINING ALLOWANCES

Standard 8, which completes the series now published by Z.A.D.C.A., relates to stock allowances for machining. For die cast components, the provision of stock allowance is generally associated with draft on side walls, although occasionally bosses are faced to height. An illustration showing the two possible requirements, as in Fig. 7, might well have been included in the standard. The important point, of course, is to provide enough metal to ensure that the tool does not run out on to the as-cast surface.

FLASH REMOVAL

Z.A.D.C.A. standards, unlike the A.D.C.I. standards, are not concerned with the requirements for flash removal. In this country, most die castings are now press-trimmed to a considerably greater degree of precision than is demanded by the U.S. "commercial" standard. The exact extent to which flash-removal, deburring, rectification of casting taper, and similar minor operations are to be apportioned between die caster and customer is, however, essentially a matter to be decided by discussion.

There is no doubt that "Engineering Standards for Pressure Die Casting" will prove of very real value to designers of products in which die castings are incorporated. The standards provide a comprehensive range of tolerances, and if some of

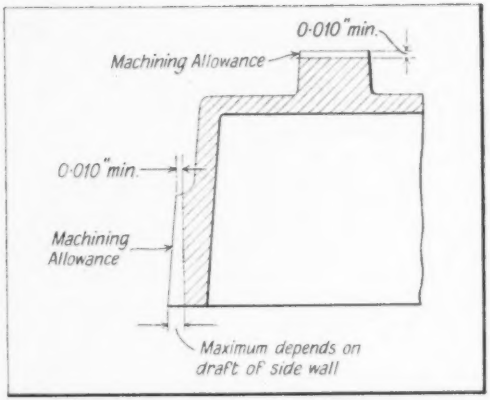


Fig. 7. On Surfaces Substantially Parallel to the Plane of the Parting it Suffices to Allow 0·010 in. of Stock for Machining as on the Boss at the Top in the Figure. On Surfaces with Draft the Excess Stock should Provide a Minimum of 0·010 in. at the Thinner Edge

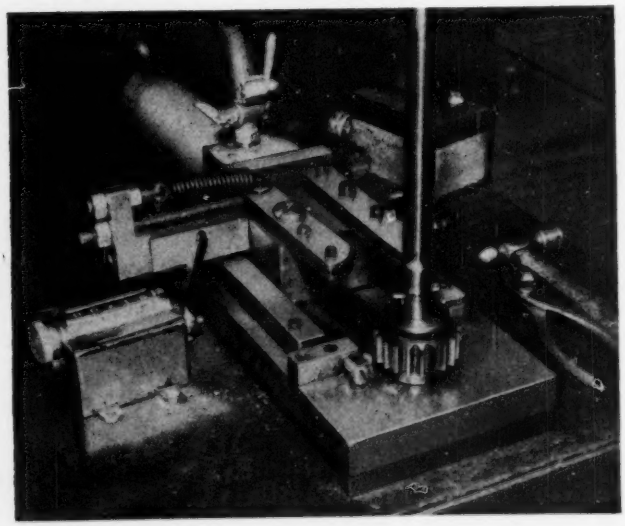
them seem to be a little wider than necessary, at least the prospective buyer may be assured that the limits thus established can be maintained by die casters of even moderate competence. It is to be hoped that the standards will find wide acceptance among all who have occasion to specify tolerances for die cast components, for there is no doubt that wide limits are of material assistance in raising production speeds, and, at the same time, enable soundness and surface finish to be improved. Where close limits are really essential, the industry will doubtless continue to maintain them, and can even be expected to improve upon present possibilities of dimensional accuracy as equipment is further developed and production comes more and more under fully automatic control.

A Pneumatic Cotter-pin Spreader

The air-operated device here shown is employed at the works of the Clyde (Ohio) Division of the Whirlpool-Seeger Corporation, U.S.A., to facilitate an assembly operation.

After a gear and a washer have been passed over the long agitator shaft of a washing machine, the assembly is placed in the fixture shown. The cotter-pin is then inserted in a hole in the shaft at a position approximately 1 in. above the gear, the shaft being located by a recess in the base of the fixture. Behind the shaft there is an air-operated slide that advances and quickly retracts when a palm button is pressed. Two slotted jaws are carried on the slide, the one at the right being bolted in position, whereas the jaw on the left can pivot clockwise. A spring and an adjustable stop hold the pivoting jaw in a pre-set position.

When the slide advances, the slot in the jaw on the right engages the head of the cotter-pin and holds it horizontal. The other jaw then travels over the point of the cotter-pin until the longer prong enters a recess in the bottom of the slot. As this jaw continues its outward stroke the long prong is bent forward. Both jaws are returned when the palm button is released, and the assembly is then removed. Since the operator holds the shaft near the top with one hand and presses the button with the other, there is no risk of injury.



Air-operated Equipment for Spreading Cotter-pins

The Work of P.E.R.A.

During 1957, the Production Engineering Research Association of Great Britain, Melton Mowbray, Leicestershire, occupied a new research block, which has been provided at a cost of £250,000, and established a new Education and Training Department. A view showing part of the new workshops and laboratories is given in Fig. 1. More than 120 large and small firms, in a wide range of industries, joined the Association last year.

In addition to general investigations, some 230 special problems and developments projects were examined for individual member firms, and reference is made here to certain aspects of this work. Members also requested technical assistance in connection with about 2,600 specific problems, concerned with various aspects of production, including works layout, finishing, mechanical handling, welding, work study, design for production, and inspection.

A form of associate membership is now open to all technical colleges and universities in Britain and the Commonwealth, and a number have already been elected to membership. Various P.E.R.A. services are available to associate members, who are also being encouraged to collaborate on research projects related to industry's needs for reliable information about various aspects of production.

COURSES FOR KEY EMPLOYEES

Following the success of last year's courses for key employees in industry, all the educational activities of the Association have been assigned to a new Education and Training Department, and permanent training facilities have been established in the former research laboratories. Greatly improved lecture theatres and a demonstration bay are therefore available for all courses, and equipment has been specially allocated for practical demonstrations of production techniques.

At the request of members, the general course on improved production techniques was repeated in 1957. The subjects covered by this course include metal forming, automation, metal cutting, machine tool utilization, method study, and inspection. A new series of courses on metal cutting began during June, and was attended by hundreds of foremen, shop managers, superintendents, and methods engineers. Case studies and group discussions were found to be of importance in stimulating member firms' employees to seek opportunities for applying the Association's recommendations to production operations. In addition to the examination of the effects of changes in well-established production techniques, the courses included an outline of the advantages of recently developed techniques, together with sufficient information on the economics of each technique to assist firms in selecting those most suitable for their purposes.

Fig. 1. A View in the New P.E.R.A. Workshops and Laboratories

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Short refresher courses were also held for workshop employees, such as foremen and tool grinders, for example, on machine tool maintenance, press setting, tool and cutter grinding.

More than 20 young engineers took a six-month course which included practical experience with P.E.R.A. research teams, lectures on various aspects of production from senior research engineers, a series of organized discussions, and visits to factories specially selected to demonstrate the application of up-to-date production techniques in various industries. This course has now been taken by more than 100 young engineers, and each student participates directly in the solution of a variety of production problems.

The Mobile Unit visited approximately 140 factories in Scotland and the North of England. During 1958, this Unit will gradually travel South, through the Midlands and the rest of England, spending one to three days at members' factories.

COLD EXTRUSION INVESTIGATIONS

Considerable progress has been made in investigations into the impact (cold) extrusion of steel, and experiments have recently been started on the cold extrusion of large components on a 1,000-ton press. Current research also covers investigations into the properties of steels for impact extrusion, variations in extrusion pressure with percentage reduction in area, and the conditions of lubrication required for backward extrusion. Despite the tremendous possibilities of the cold extrusion process as a means of reducing capital expenditure, floor space, handling, operation times, and material consumption, in the production of a wide range of products, application of the technique in Britain has been restricted, it is stated, by the lack of reliable data on tool design and on the extrusion properties of materials. Development work which the Association is at present carrying out, for various firms, is expected to result in savings of the order of £40,000 per year in the production of one type of component alone.

FINISH-BLANKING TECHNIQUE

Research has been continued into the P.E.R.A. finish-blanking technique, which produces pressings with smooth edges in contrast to the relatively rough edges produced by conventional blanking methods. This technique frequently eliminates expensive shaving or machining operations on pressings, and is being applied in an increasing number of industries. One firm, achieved a saving of £3,000 in the production of the first component to which finish-blanking was applied. Still wider application of the technique is expected when research work on other materials has been completed.

METAL CUTTING RESEARCH

Following research into the drilling of cast iron, investigations have been carried out to determine the most suitable point shapes for drilling various steels. Significant increases in drill life have been achieved with point shapes differing from those conventionally used in production. Current research includes an investigation on an automatic lathe to compare the performances of three types of high speed steel when machining alloy steel. Opportunity is being taken, during this investigation, to obtain information on the relationship between tool wear and workpiece diameter. Research is also in progress to compare the performances of various cutting fluids, and the effects of different methods of applying cutting fluids, when machining high-tensile nickel-chrome steel with carbide tools.

FURTHER REAMING INVESTIGATIONS

A previous investigation into the effect of reaming conditions on hole accuracy and surface finish showed that there are critical values of cutting speed and feed rate, above which the accuracy and surface finish of reamed holes deteriorate rapidly. As these values are the limiting factors in preventing the use of higher cutting speeds and feed rates, it is considered important to determine whether improvements in performance could be achieved by changes in reamer shape. Research has been carried out, therefore, to ascertain the effects of reamer shape on accuracy and surface finish. Changes in rake and circular land width influence hole surface finish, and the test results also indicated that swarf jamming has an important influence on reamer performance. Other factors investigated included chamfer angle and flute length, and the effect of built-up edges on accuracy and surface finish.

PERFORMANCE OF CERAMIC TOOLS

An investigation into the performance of a range of makes of ceramic tools when turning alloy steel is almost complete. Comparison tests have been carried out on cemented carbide tools, and performance was assessed on the basis of tool wear in roughing operations, and on workpiece surface finish and wear in finishing operations. Economic aspects of the use of ceramic tools were explored by carrying out tests to determine the effects of various feed and speed combinations which give constant rates of metal removal.

TOOL GRINDING TECHNIQUES

Field investigations into problems concerned with cutting tool performance have emphasized the need for improved grinding techniques and a greater degree of control. An investigation, in which conventional and unorthodox methods of grinding carbide tools were studied, indicated that the speed and ease of grinding associated with a particular method were of considerable economic significance. The effect of the method of grinding on carbide tool life was also investigated.

Recommendations based on these results are being applied in industry, and savings in the form of reduced grinding wheel costs, and longer tool life between regrinds, have been reported.

RESEARCH ON MACHINE TOOLS

An investigation into the accuracy and performance of several makes of cylindrical grinding machine has been completed, and substantial progress has been made in an investigation into various aspects of machine tool slideway lubrication and slideways. A report is being prepared on the influence of scraped surfaces, lubricant viscosity, load per unit area, and sliding speed, on the transition from boundary to hydro-dynamic lubrication. Practical tests are also being carried out to determine the friction properties of various lubricants and machine tool slideway materials.

VIBRATION EFFECTS

It is not generally realized that present limits of feed, speed, tool life, surface finish, and accuracy, in many production operations, are determined by the vibration characteristics of machines and cutting tools. The difficulties caused by vibration are usually readily apparent in operations such as boring and milling, but in many apparently vibration-free operations, limitations on output and quality are, in fact, often imposed by minute, undetected vibrations. Full understanding of the nature and effects of these vibrations will help to remove present barriers to substantial increases in the efficiency of existing techniques, facilitate the development of new techniques, and lead to more efficient utilization of carbide and ceramic cutting tools.

By using experimental vibration absorbers now being developed by P.E.R.A., excellent surface finishes can be produced at some machining operations under conditions which otherwise result in severe chatter, rough surfaces, and, in extreme cases, tool breakage. Other investigations have indicated that the reduction or elimination of vibration often obviates the need for subsequent finishing operations such as reaming or grinding, so that machining times and costs are reduced.

A growing number of makers and users of machine tools recognize the need for trained engineers who can interpret and apply the results of vibration research, and several member firms have seconded engineers to the Association for periods of training lasting for at least 12 months. These engineers receive instruction in subjects necessary for complete understanding of vibration phenomena, and assist P.E.R.A. staff engaged on practical research into vibration. In Fig. 2, an engineer, engaged on a training course, is carrying out tests with an experimental, damped boring bar. With a bar of this type, it is reported, excellent surface finishes have been produced in some instances where considerable difficulty was previously experienced in obtaining satisfactory results.

Fig. 2. An Experimental Damped Boring Bar is here being Tested

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The course includes investigations into the vibratory characteristics of machine tool structures and elements, and cutting tools, correlation of theory and practice, and the analysis, interpretation, and practical application of experimental results.

AUTOMATION

As nearly all firms, both large and small, will ultimately be directly affected by the many developments now taking place in automation, an operational research is being carried out into a wide range of automation equipment. A report on hoppers and selector devices was recently issued to members, and subsequent reports will cover work loading equipment such as magazines, mechanical hands, and iron hands; working clamping equipment; work conveying equipment; the application of various types of automation equipment in machining and press-working operations; and transfer machine tools and presses. To obtain direct experience of the problems involved in automation, and to expedite the Association's investigations, a number of member firms have seconded one or more of their engineers to P.E.R.A. for periods that may extend to several months.

INFORMATION SERVICES

Very heavy demands were made on all information services in 1957. Examples of gains in productivity, by firms which applied P.E.R.A.'s recommendations, include a 300 per cent rise in turnover by a manufacturer of metal furniture. The output of a firm making handling plant was increased by more than 30 per cent, and the introduction of better production methods saved another company £20,000 per year.

Typical of the problems that have recently been submitted is that of a company which must concentrate its production into a building roughly half the size of the existing works, to obtain vitally needed storage space. By means of improved tooling, more efficient equipment, and "streamlined" handling and transportation, the new production plan will enable output to be trebled in half the present floor space.

Films have been made by the P.E.R.A. Film Unit on a variety of subjects, including cutting fluids, drilling, and carbide tools. These films give practical guidance to industrial employees in applying improved production methods, and are playing an important part in stimulating prompt application of the results of the Association's researches. A film is at present being made on methods improvement, in collaboration with a number of member firms.

Books Received

THE IRON AND STEEL TRADES IN 1957. William Jacks & Co., Ltd., Winchester House, Old Broad Street, London, E.C.2.

This special review includes useful information under such sub-headings as production, stock changes, raw materials, iron ore requirements, costs and prices, imports and exports, new methods, scrap supplies, and "the outlook."

THE RUGBY ENGINEERING SOCIETY—PROCEEDINGS, 1956-57. Care of Publicity Department, British Thomson-Houston Co., Ltd., Rugby. [Price 10s. 6d.]

In this publication the presidential address on Science-Schools-Industry is reproduced, also the following papers: automatic electronic control of machine tools, applications of radio-isotopes, the free piston engine, and electric power drives and closed-loop control.

KEMPE'S ENGINEERS YEAR-BOOK, 1958 (two volumes). Morgan Brothers (Publishers), Ltd., 28 Essex Street, Strand, London, W.C.2. 2,800 pp. [Price 82s. 6d. net.]

In the 63rd edition of this important year book, various changes and additions have been made to keep the subject matter up to date. The section on welding and cutting, for example, has been rewritten to cover argon arc welding, self-adjusting arc welding, controlled arc welding, gas shielded arc cutting, spark machining, oxygen cutting, and hard-facing. Revisions and additions have also been made to the following sections, among others: iron and steel; non-ferrous metals and alloys; foundry practice; grinding and abrasives; machine tools; wire ropes; railway engineering; aerodynamics; aircraft propulsion; electronic engineering; atomic power; and heating, ventilating and air conditioning.

In this way, the high standard set by previous editions has been fully maintained.

LA MACHINE-OUTIL (VOL. V)—USINAGE DES DENTURES ET FILETS. Edited by A. R. Métral. Dunod, 92 Rue Bonaparte, Paris 6e. 614 pp. [Price 8,800 francs.]

Concerned with the machining of gears and screw threads, this book comprises seven sections, each contributed by a separate authority. The first, by Y. Renard, deals with the hobbing of gears, and describes variants of the process. Production of gears by pinion and rack type cutters is covered by M. Paul, who explains the action of the Sykes, Maag and Fellows machines. The third section, by J. Bergère, is devoted to the correction of gears. His treatment is very thorough, and the gears discussed include internal and helicoidal types. F. Rochat then gives considerable information on straight and spiral bevel gears with particular reference to the Fiat and Oerlikon systems. In addition, the Klingelnberg and Gleason machines are described. Methods of gear testing explained by M. Chalvet include the use of profile testers, pitch checking, both with stationary and portable instruments, and the usual caliper and across-cylinder methods. The same author is responsible for the section on modern gear-finishing methods in which reference is made to grinding, shaving, and lapping, also electrolytic and chemical treatments. The final section, by J. Petri and P. Gantier, is devoted to screw thread production by cutting, rolling, chasing, tapping, grinding, and milling.

New Buck & Hickman Showrooms

Mention has already been made in MACHINERY, 92/110—10/1/58, of the new offices and showrooms which have been opened at the works of Buck & Hickman, Ltd., Otterspool Way, Watford By-Pass, Watford. The building, of two storeys, has been erected in what was the forecourt of the works, and forms an entirely new frontage. A showroom of some 12,000 sq. ft. is provided on the ground floor, adjacent to the main entrance and reception, and the upper floor is devoted to the administration offices, also a well-appointed canteen.

The showrooms are intended principally for display and demonstration of a representative selection from the very wide range of British-built machine tools, small tools, and gauging instruments, which the company stock and distribute, and potential customers have full facilities for observing the equipment in operation. A view of part of the showroom is given in Fig. 1. Some 65 machine tools are at present installed which include, for example, lathes by Holbrook, Colchester, Smart & Brown, Boxford, Cardiff, Stanley, Crowthorne, Woodhouse & Mitchell, and Harrison, the latter including the type L16 arranged for hydraulic copy turning. Hydraulic copying equipment, of the firm's own design, for the production of dies and moulds, can also be demonstrated on a Holbrook type M15/20 lathe, a close-up view of which is shown in Fig. 2. Transverse movement of the cross-slide, to produce an elliptical or other non-circular form, is controlled by a stylus head and rotating template mounted at the rear, the template being driven from the headstock spindle. Another stylus unit at the front, in conjunction with a flat

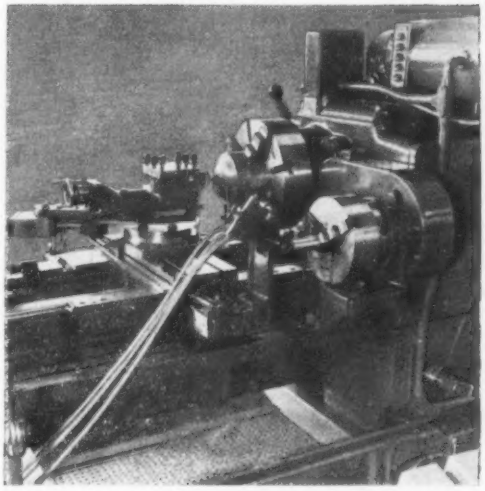

Fig. 2. Close-up View, from the Rear, of the Holbrook Type M15/20 Mould-makers' Lathe

Fig. 1. A View of the New Showrooms of Buck & Hickman, Ltd.

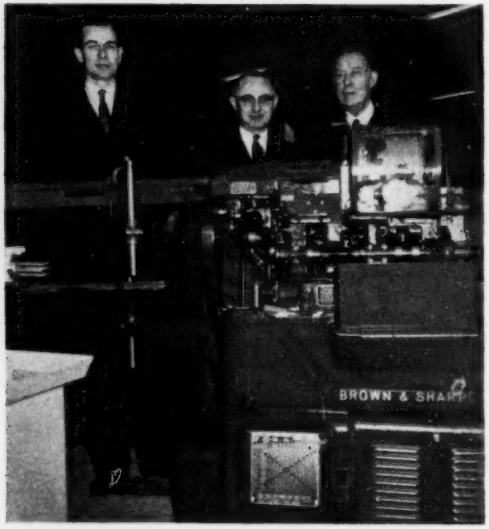

Fig. 3. A British-built Brown & Sharpe 00G Automatic in the New Showrooms of Buck & Hickman, Ltd. Mr. T. Twallin (left), Mr. G. W. Nash, and Mr. C. G. Twallin, Directors of the Company, are in the Background

template, controls the top slide movement to produce the required form in the axial direction.

Attention is drawn to a British-built Bryant 1109 internal grinder fitted with a high-frequency spindle head, also to the Brown & Sharpe 00G single-spindle turret automatics which are now being made in this country. One of the latter machines is seen in Fig. 3, with Mr. T. Twallin (left) Mr. G. W. Nash, and Mr. C. G. Twallin, directors of Buck & Hickman, Ltd., in the background. The company is also the sole agent here for "American" radial drilling machines, which are now being made in Holland, and a 5-ft. machine is available for demonstration.

Mention may also be made of a B.N.L. vertical-spindle hydraulic surface grinder made by the British Northrop Loom Co., Ltd., who, in addition, are to introduce a 10- by 24-in. hydraulic universal grinder. Pacera machines equipped with air-hydraulic feed units include a 3-spindle tapping machine, a single-spindle machine arranged with incremental feed for deep hole drilling, and a magazine-loaded machine for tapping and side-hole drilling operations on nuts. An extensive range of machine tools made by the Victoria Machine Tool, Co., Ltd., may be noted, including a Victomatic 18-in. production milling machine.

Measuring and inspection equipment available includes the entire range of Shadomaster optical projectors made by Watson Manasty, Ltd., a recent development being the type VMP which incorporates facilities for measuring to 0·0001 in., by means of micrometer drums and dial gauges. The co-ordinate measuring capacity is 2 in. by 1 in. Standard thread charts, also special charts and work-holding fixtures, can be supplied to meet requirements. The largest Shadomaster projector made, known as the Magnum, has a 30-in. diameter screen.

In addition, there is an interesting display of Magna-Gage inspection equipment made by Southern Instruments, Ltd., which includes electronic comparators reading to 0·00001 in., signal light indicators, and probes. The standard signal light indicators can be coupled together and used, in conjunction with an amplifier, for sorting purposes. Another noteworthy development is a 6-channel light signal indicator made by Parnum Gauges, Ltd., whereby, upon the depression of a push button, the six readings are automatically given, one after the other, in only 2 sec., and retained. Provision is made for obtaining single readings by depressing another button, and each station can be set individually for tolerance.

Trade Publications

MONOMETER MANUFACTURING CO., LTD., Savoy House, 115-116 Strand, London, W.C.2.—Leaflet concerned with a new design of adjustable swinging-arm unit for preheating all sizes of ladles used in iron and non-ferrous foundries. The unit can be arranged for gas or oil firing.

VERROLEC, LTD., 27 Balfour House, Finsbury Pavement, London, E.C.2. Folder describing the Elektus midget portable electric chain hoist of which various types are available for working loads up to 10 cwt. The company are now marketing the hoists in this country.

THE DRAYTON REGULATOR & INSTRUMENT CO., LTD., West Drayton, Middlesex. Fully illustrated publication of 40 pages devoted to the Drayton Armstrong steam trap. The first part is concerned with available types, and includes data tables, dimensions, and a capacity chart. Part two covers the selection and sizing of steam traps for particular applications, and part three comprises sections on installation, maintenance, and trap troubles.

LEICESTER, LOVELL & CO., LTD., North Baddesley, Southampton. Technical Service Bulletins Nos. 169 and 310C give particulars of Epophen epoxy resins for making mouldings laminated with glass or other fibres, and for making plastics tools. In the latter bulletin, instructions are included for making metal-forming tools; sand-forming tools such as foundry patterns; plastics-forming tools; and checking tools. Tool compositions and properties are summarized in two useful tables.

News of the Industry

Halifax

Although reasonably well employed at the present time, most local machine tool makers express concern at the steady decline in the volume of new business booked during recent months from both home and overseas customers. Standard and smaller types are more affected than the larger and special-purpose machines, and for the former, early or stock delivery can frequently be offered. There has already been some reduction in the amount of overtime and week-end working in many plants.

WILLIAM ASQUITH, LTD., in addition to their standard radial, transportable, and vertical drilling machines, and horizontal boring machines, are building unit-head production machines, special-purpose types, and line-transfer machines for the motor car industry. Our attention was drawn to the boring head for another 10-in. spindle ram-type horizontal boring machine, which is being erected at the firm's Shrewsbury works, and to various machines ready for despatch to the central maintenance workshops of the steelworks in India which are being constructed by British firms. The company's principal export markets are Canada, U.S.A., Australia, South Africa, and India. Recent additions to plant include an Asquith 8-ft. radial drilling machine, a Churchill 40-in. swing plain grinding machine to admit 23 ft. between centres, a Swift 28-in. swing lathe to admit 33 ft. between centres, a batch of Ward combination turret lathes, a Cridan screw-cutting lathe, and a Bohle horizontal milling machine.

THE BUTLER MACHINE TOOL CO., LTD., are well employed on the production of planing, shaping and slotting machines, for customers both at home and abroad. We may note double-standard planing machines up to 10 ft. width capacity, and open-side-type machines up to 7 ft. In addition, orders are in hand for axle-box planing machines, 36-in. stroke openside crank-type planers, and 30-in. square by 6- and 8-ft. stroke hydraulic openside machines. Shapers in progress include 18- and 26-in. stroke super machines, 18-in. stroke hydraulic types, and a 30-in. stroke draw-cut machine for motor yokes. In the slotting machine section we may note high-production machines ranging from 14- to 36-in. stroke, puncher-type machines up to 54-in. stroke, and high-precision machines of 8-, 12- and 16-in. stroke. Overseas destinations for the various products include Australia, South Africa, India, Canada, France, and Spain.

FREDK. TOWN & SONS, LTD., are fully occupied with the production of standard and girder-type radial drilling machines, ranging from 3- to 8-ft. radii, also medium- and heavy-duty box-body vertical drilling machines. Approximately 65 per cent of the orders in hand is destined for abroad, the principal markets being South Africa, Canada, Australia, and India.

CHURCHILL-REDMAN, LTD., have orders in hand for Churchill-Fay multi-tool lathes, heavy-duty lathes, shaping machines, and hydraulic profiling lathes. Recent developments, to which we hope to make further reference in due course, include a new automatic multi-tool and profile-turning lathe, a 36-in. swing surfacing and boring lathe with template-controlled slides, and Churchill-Fay multi-tool lathes with automatic loading and transfer mechanism. Recent additions to plant include a Butler 20-ft. by 4-ft. 6-in. square planing machine, a Holbrook toolroom lathe, and two multi-spindle boring machines of the firm's own make.

F. PRATT & CO., LTD., are experiencing a good demand for their various types of independent and self-centring lathe chucks, and faceplate jaws, on both home and export account. Among other active lines may be mentioned circular and rectangular permanent magnet chucks, hydraulic chucks, pneumatic machine vices, stationary oil hydraulic cylinders, and Woodworth standard air-operated diaphragm chucks.

KITCHEN & WADE, LTD., have a variety of work in hand, including standard- and girder-type radials up to 10-ft. radius, vertical drilling machines, and horizontal drilling and boring machines with spindles from 1½ to 4 in. diameter. Unit-head machines with multi-spindles, for both horizontal and vertical drilling, are in good request. A 6-spindle marine boiler shell drilling and reaming machine, which weighs 63 tons, has recently been completed for Vickers-Armstrongs, Ltd., Barrow-in-Furness. It has three columns and the maximum and minimum distances between spindles are 20 ft. and 15 in. Two tables, measuring 6 ft. by 5 ft. 3 in., are provided with power motions, and the maximum distance from the spindles to the tables is 10 ft. 6 in. Power traverses are available for the spindle saddles on the cross-rail and for the elevation of the cross-rail. Six speeds

and three feeds are available for each spindle. The overall height of the machine is approximately 20 ft. Another interesting machine, destined for the Stanton Ironworks, Ltd., provides for simultaneously facing the ends of pipes. We hope to make further reference to both these machines in due course. A good request for motorized work tables of various sizes is reported. We may note recent export business with the U.S.A., a batch of 10-ft. radial drilling machines having recently been supplied, and other export markets include Canada, Australia, New Zealand, South Africa, Belgium, Switzerland, and Sweden.

GRAHAM & NORMANTON, LTD., inform us that there is a brisk demand for lathes ranging from 19- to 25-in. centres. Three 15½-in. centre break lathes are on order for maintenance workshops of the National Coal Board, a 25-in. centre lathe for a Sheffield steelworks, and a 72-in. swing surfacing and boring lathe for a Scottish coal-cutting machinery works. We may note the recent completion of eight single-purpose boring lathes for a Sheffield steelworks. A new design of 11/13-in. centre lathe has been developed, particularly for the American market. Granor lathes have recently been added to the plant.

AUGUSTS, LTD., are steadily employed on foundry mechanization equipment for the motor car and steel industries, and on August-Simpson foundry sand and refractory preparation plants, the range of which has recently been extended. We may note that sand mixing plants are on order for India.

CARTER & WRIGHT (ENGINEERS & MACHINE TOOLS), LTD., are occupied on their standard range of keyway cutting and slot drilling machines, including the internal vertical type, and on three sizes of chip crushing machines. A girder facing machine with 12 in. cutter head has recently been developed.

AJAX MACHINE TOOL CO., LTD., report a steady demand for bench- and column-type drilling machines, bench- and pedestal-type milling machines, universal converters, polishing heads, and second-operation machines. Radial drilling machines of 54- to 66-in. radii, girder-type machines from 6- to 8-ft. radii, and the recently-developed AJ35, with elevating table and radii of 36 and 48 in., are also in good request. We may note recent orders for radial drilling machines from the U.S.A., Canada, South Africa, India, Holland and Belgium.

WRIGHT ELECTRIC MOTORS (HALIFAX), LTD., are supplying 7½- and 25-h.p. electric motors for driving Sulzer pumps for the South African gold mining industry. A steady business in Electrosuds pumps is reported with the machine tool industry. Other products of the company include a range of table surface grinding machines, centring machines, and grinding heads.

J. SAGAR & CO., LTD., state that the call for 3-drum sanders, 4-cutter planing and moulding machines, and 30- and 36-in. bandsawing machines, is fully maintained, and larger numbers of these machines are being built. Orders are in hand on both home and export account, and the Building Trades Exhibition, held last year, provided a useful stimulus to business. H. B.

E.I.A. North East London Display

A successful evening display was held on January 23, at Ilford Town Hall, by the Engineering Industries Association, North East London Group. Some 70 member firms of the Association participated in the event, which was well attended and served to draw attention to the wide range of products made within the Group.

Among the exhibitors the following may be noted: Hilger & Watts, Ltd., Langston Road, Loughton, Essex, a range of engineers' instruments, block levels and microscopes; David Dowling, Ltd., Roebuck Road, Hainault, Essex, a selection of machined parts and an example of the firm's range of engraving machines; Claude Rye Bearings, 895-921 Fulham Road, London, S.W.6, a variety of ball and roller bearings in which they specialize; Benton Engineering Co., Ltd., Tonbridge Road, Harold Hill, Essex, repetition work, produced on multi- and single-spindle automatics up to 1⅝ in. diameter, and the recently introduced Wunop rivet bush; J. L. Holden Co., 19a Rock Street, Brighton 7, Sussex, representative examples of a wide range of milling cutters and machine hacksaw blades reconditioned in their works; Aviation Developments, Ltd., Kingsborne House, 229 High Holborn, London, W.C.1, the use of Chobert rivets for assembly work, with manually-operated or pneumatically-powered riveters; N. V. Tools, Ltd., Queens Road, Brentwood, Essex, examples of contract press work, jigs and fixtures; Telco, Ltd., 3 Newman Street, London, W.1, a wide selection of screws, nuts, and studs; Teleflex Products, Ltd., High Road, Chadwell Heath, Romford, Essex, examples and several photographs of their conveyor equipment; Price & Tarling, Ltd., 2a Jumpers Avenue, Christchurch, Hants., an extensive range of aluminium die castings, including several fittings of a type used in irrigation systems overseas; H. Rollet & Co., Ltd., 6 Chesham Place,

S.W.1, a representative selection of metals from stocks which include stainless steel and non-ferrous materials; Brown's Engineering Works, 246-250 High Road, Loughton, Essex, a wide variety of machined and small fabricated parts; Murray's (Pretoria) Engineering Co., Ltd., 26/28 Pretoria Road, Romford, small tools, T-bolts and a selection of the company's range of standard jig parts; The Delta Metal Co., Ltd., Tunnel Avenue, East Greenwich, London, S.E.10, extensive range of non-ferrous extruded sections; Larmar Engineering Co., Ltd., Margaretting, Ingatestone, Essex, small tooling equipment and a wide selection of small machined parts; Rotheroe & Mitchell Ltd., Aintree Road, Perivale, Middlesex, various exhibits, including a nuclear fission dust monitor; Enfield Rolling Mills, Ltd., Millmarsh Lane, Brimsdown, Enfield, prominent display of Encon continuous cast bronze products; and Patron Engineering Co., Tonbridge Road, Harold Hill, Essex, an adjustable, double tangential roller steady, box tool.

Sensitive Movement of Machine Tool Slides

(*Continued from page* 231)

bolt. It has also been shown that a slide supported in this manner will move under its own weight if the guiding surface is only very slightly inclined, so that the arrangement constitutes, in effect, a precision level.

It is unnecessary to labour the importance of a system which, without mechanical complication, will permit sliding movement virtually without friction, and the principle could doubtless be widely adopted with very substantial advantages. At the same time, it would appear possible that the ability to maintain a constant separation between surfaces nominally in engagement, by interposing a pressurized layer of oil, might be turned to account in a variety of other ways.

Coming Events

INCORPORATED PLANT ENGINEERS. *Edinburgh Branch.* February 4, at 7 p.m., at 25 Charlotte Square, Edinburgh; paper on "Testing of Engineering Materials, Destructive and Non-Destructive, by Mechanical, Chemical, X-ray and Ultrasonic Means," by J. A. Menzies. *Peterborough Branch.* February 4, at 7.30 p.m., at the White Lion Hotel, Church Street, Peterborough; paper on "Optical Engineering," by J. Hobbs.

THE INSTITUTE OF METAL FINISHING. *Scottish Branch.* February 4, at 7.30 p.m., at the Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow; film on "Electrostatic Spraying," by R. Tilney. *North-West Branch.* February 6, at 7.30 p.m., at the Engineers' Club, Albert Square, Manchester; papers on "Barrel Enamelling," by W. S. Field, and "Centrifugal Lacquering," by J. G. Lemon.

JUNIOR INSTITUTION OF ENGINEERS. February 7, at 7 p.m., at the Institution, Pepys House, 14 Rochester Row, Westminster, London, S.W.1; film evening, "The Wickman Erodomatic," and other films by Wickman, Ltd. *North-West Section.* February 10, at 7.30 p.m., at the Engineers' Club, Albert Square, Manchester; paper on "A Practical Approach to Surface Finish," by L. Hough.

INSTITUTION OF PRODUCTION ENGINEERS. *Coventry Graduate Section.* February 5, at 7.15 p.m., at Smiths Stampings (Coventry), Ltd., Ribble Road Works, Humber Avenue, Coventry; film on "American Die Forging Practice," followed by question period and tour around factory. *Wolverhampton Section.* February 5, at 7.15 p.m., at the Wolverhampton and Staffs. College of Technology, Wulfruna Street, Wolverhampton; lecture on "The Use of Punched Card Methods for Production Control," by J. C. Davies. *Nottingham Section.* February 5, at 7 p.m., at the Victoria Station Hotel, Nottingham; lecture on "Metallurgy in Production," by H. D. Ward. *London Section.* February 6, at 7 p.m., at Creed & Co., Ltd., Telegraph House, East Croydon, Surrey; lecture on "Achieving Economic Production from your Press Shop," by J. J. Gallway, assisted by P. H. Steer and L. E. Smith. *Gloucester Section.* February 6, at 7 p.m., at the North Gloucestershire Technical College, The Park, Cheltenham; film on "Gear Hobbing," by Vaughan Associates, Ltd. *Sheffield Section.* February 10, at 6.30 p.m., at the Grand Hotel, Sheffield; lecture on "Automation in the Steel Industry," by Dr. R. H. Baulk.

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31/1/58

Industrial Notes

EVERSHED & VIGNOLES, LTD., have opened a branch office in Belgium at Succersale, 142 Rue Gallait, Brussels.

W. O. BULLOCK & SONS, LTD., 126, Rodhouse Road, Swindon, Wilts., have been appointed agents for Crawford Collets, Ltd., for South West England and Wales.

THOMAS SMITH & SONS, RODLEY, LTD., Rodley, Leeds, have received an order from the Government of India for 27 diesel and steam cranes, valued at nearly £300,000.

AVELING-BARFORD, LTD., Grantham, have secured a contract from the Argentine, valued at £1 million, for the supply of 170 of their 10-ton motor graders for road building.

LANCASHIRE DYNAMO GROUP SALES, LTD., The Nottingham area sales office of this company is now at 2 St. James's Terrace, Standard Hill (telephone number, Nottingham 43025/6).

HUNT & MITTON, LTD., Oozells Street North, Birmingham, inform us that they have been awarded an important contract for the supply of high-pressure valves for a new automatic rubber moulding plant in the U.S.S.R.

OIL FEED ENGINEERING CO., LTD., 18 Denbigh Street, Victoria, London, S.W.1, makers of high-pressure flexible hose assemblies under the name Hi-Flex, has now become a member of the B.T.R. Group of companies and will operate as the High Pressure Hose Division.

S. N. BRIDGES & CO., LTD., recently acquired new premises at 15 Quay Street, Manchester, 3, and sales and service facilities are now available from this address (telephone numbers, service—Deansgate 4928, and sales department—Deansgate 4929).

SMART & BROWN (MACHINE TOOLS), LTD., 25 Manchester Square, London, W.1. Spare parts booklets are now available for the company's M and 9-in. swing precision bench lathes, types SABEL, SAB, and S, and may be obtained from the above address, or from stockists.

COMBUSTION ENGINEERING ASSOCIATION, 6 Duke Street, St. James's, London, S.W.1.—The report of the successful conference on the N.I.F.E.S. Third Progress Survey, which was held at Harrogate in November last, is now available (price 21s.) from the above address.

CEROC SINTERED CERAMIC CUTTING TOOLS, made by Compagnie Générale d'Electro-Ceramique, France, which were described in an article published in MACHINERY, 91/1420—20/12/57, are now being marketed in this country by Machine Tool Sales (London), Ltd., 79 Portland Place, London, W.1.

SPARTAN STEEL & ALLOYS, LTD., Spartan Works, St. Stephens Street, Birmingham, 6, a recently-formed company, has taken over from LEOPOLD LAZARUS, LTD., the manufacture and marketing of their specialized iron and steel products in the United Kingdom. In all other respects, Leopold Lazarus, Ltd., will continue to trade as previously.

MACHINE TOOL DELIVERIES in October were valued at £8,978,000 (including £2,201,000 for export). Orders booked during the month totalled £6,404,000, of which £1,801,000 were for export. At the end of the month orders in hand amounted to £82,260,000, including £20,274,000 for export.

COMPUTING STRESSES IN PIPE SYSTEMS.—Ferranti, Ltd., Computer Department, West Gorton, Manchester, 12, have issued a folder giving a brief description of a programme for the Ferranti Pegasus computer, for the computation of stresses in 3-dimensional, multi-anchor pipe systems. It may be used, for example, for steam or hydraulic pipe layouts in marine or industrial engineering.

TRADE EXHIBITION FACILITIES.—As a result of the recent survey by the Federation of British Industries, 21 Tothill Street, London, S.W.1, of trade associations' views on the future of trade fairs in Britain, the F.B.I. Grand Council has approved the appointment of a Committee of Inquiry which will consider present exhibition facilities in this country and, if necessary will, recommend plans for extending them.

SEMICONDUCTORS, LTD.—The new factory which is being built for this company, at Cheney Manor, Swindon, Wiltshire, and is now nearly complete, will, it is claimed, be the most modern transistor plant in the world, and will be completely air conditioned to minimize dust. Designed and constructed by Richard Costain, Ltd., the factory is clad entirely with aluminium panelling. It has no windows and all internal surfaces are coated with P.V.C.

DISPOSAL OF CADMIUM.—The Board of Trade announce that they intend to dispose of 12½ tons of cadmium metal in rod form, which represents the final balance of the stockpile. This material is being offered immediately for sale by open tender for delivery before the end of March, 1958. Forms of Tender are obtainable from the Board of Trade, General Division 7, Lacon House, Theobalds Road, London, W.C.1.

ENGINEERING & SCIENTIFIC EQUIPMENT, LTD., 33 Minster Road, London, N.W.2, a newly-established company, are engaged in the following activities:—production of new types of electrical and electronic multi-dimensional measuring equipment, designed and built to suit particular products; importation of measuring, testing and other precision engineering equipment, also scientific laboratory equipment for industrial and basic research.

ASSOCIATION OF ENGINEERING DISTRIBUTORS, LTD., Hastings House, Norfolk Street, London, W.C.2. At the first of the 1958 series of Council Luncheons, Mr. R. F. Hatto, sales director of Wolf Electric Tools, Ltd., Hanger Lane, London, W.5, was the principal guest. After the luncheon, a Council meeting was held, at which the organization of a party to visit the forthcoming Hanover Spring Fair was discussed.

THE ELECTRIC CABLE MAKERS FEDERATION held its inaugural meeting in London on January 7. The initial membership comprises about 40 British cable-makers, comprising nearly the whole of the industry. Mr. F. Waine,

J.P., director of British Insulated Callender's Cables, Ltd., and Mr. S. Geipel, chairman of William Geipel, Ltd., were elected as its first president and vice-president respectively. The present address of the Federation is Dickens House, 15 Took's Court, Chancery Lane, London, E.C.4.

SIEMENS EDISON SWAN, LTD., at their new factory in Tottenham, are equipped to coat articles of all sizes with P.T.F.E. dispersion. Newly-installed plant includes sintering ovens, which will admit parts of very large size, and conveyor ovens for handling quantities of small items. This process it is stated, provides an inert and non-stick surface with almost zero coefficient of friction.

THE BROCKHOUSE GROUP OF COMPANIES have begun publication of a house journal known as *The Forge*. Edited by Mr. J. L. Wainford, 25 Hanover Square, London, W.1, this journal will provide information on the Brockhouse Organization companies and their products. In the first issue are included articles under the headings "castings by mechanization" and "a floating school." The latter is concerned with a new method of building with steel structures, to overcome the problem of subsidence in mining areas.

CASE STUDIES IN QUALITY CONTROL.—The Production Engineering Department of the College of Technology, Suffolk Street, Birmingham, 1, has arranged a course on case studies in quality control, which will start on February 4. This course, which will consist of eight weekly lectures, has been designed for those whose responsibility is the quality function within their own works. It will be under the direction of Mr. T. B. Worth, M.I.Mech.E., M.I.Prod.E., A.M.I.E.E., F.R.S.A., head of the department, and Mr. J. D. Morrison, B.Sc.(Eng.), A.M.I.Prod.E., M.I.E.I., senior lecturer (metrology and quality control).

STEEL AND IRON PRODUCTION IN 1957.—The Iron and Steel Board recently announced that the national output of steel in 1957 reached the record total of 21,700,000 tons, and of pig-iron, 14,300,000 tons. These figures represented increases of 5 and 8.4 per cent respectively, compared with 1956. Steel production in December, which was affected by holidays, averaged 397,900 tons a week, compared with 429,200 tons in November and 395,900 tons in December, 1956. Pig-iron production in December averaged 275,500 tons a week, compared with 281,500 tons in November, and 262,300 tons in December, 1956.

MOORE & WRIGHT (SHEFFIELD), LTD., inform us that building has started on their new factory at Handsworth, Sheffield. This single-storey factory, together with a 2-storey office block, will occupy more than 150,000 sq. ft. of the 10-acre site. The office block will incorporate a modern canteen and employees' recreation rooms. It is necessary for the company to leave the present premises on account of central area redevelopment plans, and it is anticipated that the number of employees will be increased from 800 to more than 1,000 when the new works are in full production.

CONSOLIDATION OF PATENTS RULES.—Amended rules involving minor changes in the arrangements governing patents applications and fees have been laid before Parliament by the Board of Trade. They include the introduction of a new service to the public by which information will be supplied as to whether any particular patent is in force on payment of a nominal fee of 1s. for the first patent and 6d. for each succeeding one.

These new Patents Rules, 1958 (S.I. 1958 No. 73), come into operation on February 1. Copies can be obtained from H.M.S.O., price 2s. 6d. each (by post, 2s. 10d.).

PACKERS SUPPLY CO., LTD., Agripta House, Burlington Road, New Malden, Surrey, have increased their output capacity by about 100 per cent to meet the increasing demand for their rust-resisting tensional steel strapping and strapping tools. In addition, they have extended their range of products to include a jig for use with the XLS "seal-less" tool to facilitate the strapping of light cartons; also a new tensioning tool, with separate sealing unit, for strapping rounded and irregular shapes.

Mond Nickel Fellowships

The Mond Nickel Fellowships Committee recently announced the award of Fellowships for 1957 to the following applicants:—Mr. E. J. Williams (John Summers & Sons, Ltd.), to study the research and production techniques, quality control, and metallurgy of high quality low carbon strip steel in the United Kingdom, the Continent, and the United States. Mr. R. J. D. Acheson (Mufulira Copper Mines, Ltd.), to study the extraction and refining processes for copper and allied metals, with particular reference to economic aspects.

Applications for Fellowships for 1958 are now invited. Particulars and forms of application are available from:—The Secretary, Mond Nickel Fellowships Committee, 4 Grosvenor Gardens, London, S.W.1.

Vehicle Production and Exports

The number of cars produced in 1957 was 860,842 as compared with 707,594 in 1956. This increase is the more remarkable when it is considered that for the first quarter of last year there was actually a deficit of 56,376 in comparison with the corresponding period of 1956. Commercial vehicle production in 1957, with 289,976 units, did not quite reach the level of the previous year (298,609).

Exports of cars last year totalled 426,272 (£158,061,223); of commercial vehicles, 123,283 (£87,138,142); and of agricultural tractors, 114,965 (£59,032,311). The largest single market for cars was the U.S.A. with 94,867 (£39,588,284), followed by the Union of South Africa with 42,001 (£14,076,044), and Australia with 49,056 (£13,588,759).

Australia took 15,908 (£7,973,998) commercial vehicles, and 20,302 (£9,183,458) tractors, and South Africa 13,171 (£8,819,757) and 9,647 (£4,680,886).

Correction

In the reference to the T. S. Harrison jubilee dinner, MACHINERY, 92/223—24/1/58, Mr. G. W. Nash was described as managing director of Buck & Hickman, Ltd. It should have been stated that Mr. Nash is a director of the company, responsible for machine tool activities.

Personal

MR. S. HINCHLIFFE has been appointed to the board of Dowty Seals, Ltd., Ashchurch, Gloucestershire. He is also production manager.

MR. T. E. POTTS has been appointed a managing director of the British Oxygen Co., Ltd., Bridgewater House, Cleveland Row, St. James's, London, S.W.1.

MR. JOHN TAYLOR has retired from the position of works manager of The Expanded Metal Co., Ltd., Burwood House, Caxton Street, Westminster, London, S.W.1, after 36 years of service with the company, but will remain a member of the board. He has been succeeded as works manager by MR. H. P. SALMON, who is also a director.

MR. J. W. DAVIES has retired from the board of directors of Ferranti, Ltd., Hollinwood, Lancs., after nearly 60 years' service with the company. He started work in 1898, as a toolmaker, and became toolroom foreman in 1905. He was appointed works manager of the Meter Department in 1911; general works manager in 1925; and a director in 1942. During his earlier days with the firm, he was closely associated with the founder, Dr. S. Z. de Ferranti.

Machine Tool Share Market

The feature of stock markets last week was the continued firmness of British Government and other fixed interest investment stocks, which were active, and higher at the close of the week. In other sections, very quiet conditions prevailed. Price movements were small and irregular, and the tone uncertain.

Commercial and industrial share markets were subdued, and displayed dullness for the most part. Apart from a few individual features, the majority of changes were to slightly lower levels.

Among machine tool issues, however, Arnott & Harrison rose 3d. to 14s.; Asquith Machine Tool, 3d. to 18s. 6d.; Craven Bros. (Manchester), 3d. to 5s. 9d.; Modern Engineering, 3d. to 11s.; Coventry Gauge & Tool, 7½d. to 16s. 1½d.; and John Harper, 1½d. to 14s. 4½d. On the other hand, Armstrong Stevens lost 3d. at 7s. 9d.; British Oxygen, 7½d. at 30s.; Churchill Machine Tool, 1½d. at 17s. 6d.; and Kerry's (Gt. Britain), 3d. at 5s. 9d.

B. ELLIOTT & CO., LTD.—Interim dividend 7½ per cent.

COMPANY		Demon.	Middle Price
Abwood Machine Tools, Ltd.	Ord.	1/-	1/-
Armstrong, Stevens & Son, Ltd.	Ord.	5/-	7/9
Allen (Edgar) & Co., Ltd.	Ord.	£1	29/9xd
" " "	5% Prf.	£1	15/-*
Arnott & Harrison, Ltd.	Ord.	4/-	14/-
Asquith Machine Tool Corp., Ltd.	Ord.	5/-	18/6
" " "	6% Cum. Prf.	£1	17/9
Birmingham Small Arms Co., Ltd.	Ord.	£1	26/-
" " "	5% Cum. "A" Prf.	£1	15/-
" " "	6% Cum. "B" Prf.	£1	17/6
" " "	4% 1st Mort. Deb.	Stk.	84½
British Oxygen Co., Ltd.	Ord.	£1	30/-
" " "	6¼% Cum. Prf.	£1	20/6
Brooke Tool Manufacturing Co., Ltd	Ord.	5/-	5/6
Broom & Wade, Ltd.	Ord.	5/-	10/6
" " "	6% Cum. Prf.	£1	17/9
Brown (David) Corporation, Ltd.	5¼% Cum. Prf.	£1	12/6
Buck & Hickman, Ltd.	6% Cum. Prf.	£1	17/6
Butler Machine Tool Co., Ltd.	Ord.	5/-	9/9
" " "	5% Cum. Prf.	£1	15/9
C.V.A. Jigs, Moulds & Tools, Ltd.	5½% Red. Cum. Prf.	£1	13/9
Churchill (Charles) & Co., Ltd.	Ord.	2/-	4/10½
" " "	6% Cum. Prf.	£1	26/3†
Churchill Machine Tool Co., Ltd.	Ord.	5/-	17/6
" " "	6% Cum. Prf.	£1	18/9
Clarkson (Engrs.), Ltd.	Ord.	5/-	10/6
Cohen (George), Son & Co., Ltd.	Ord.	5/-	10/6
" " "	4½% Cum. Prf.	£1	14/3
Coventry Gauge & Tool Co., Ltd.	Ord.	10/-	16/1½
" " "	5% Cum. Red. Prf.	£1	13/9
Coventry Machine Tool Works, Ltd.	Ord.	4/-	8/6
Craven Bros. (Manchester), Ltd.	Ord.	5/-	5/9
Elliott (B.) & Co., Ltd.	Ord.	1/-	3/-
" "	4½% Red. Cum. Prf.	£1	13/9
Export Tool & Case Hardening Co., Ltd.	Ord.	2/-	1/9
Firth Brown Tools, Ltd.	4% Cum. Prf.	£1	12/-
Greenwood & Batley, Ltd.	Ord.	£1	46/10½xd
Harper (John) & Co., Ltd.	Ord.	5/-	14/4½
" " "	4½% Red. Cum. Prf.	£1	12/9
Herbert (Alfred), Ltd.	Ord.	£1	57/6
Holroyd (John) & Co., Ltd.	"A" Ord.	5/-	11/-
" " "	"B" Ord.	5/-	10/-
Jones (A. A.) & Shipman, Ltd.	Ord.	5/-	23/9
" " "	7% Cum. Prf.	5/-	5/-
Kayser, Ellison & Co., Ltd.	Ord.	£1	54/-
" " "	6% Cum. Prf.	£1	18/3
Kendall & Gent, Ltd.	Ord.	5/-	7/9
Kerry's (Gt. Britain), Ltd.	Ord.	5/-	5/9
Kitchen & Wade, Ltd.	Ord.	4/-	10/9
Martin Bros. (Machinery), Ltd.	Ord.	2/-	2/4½
Massey, B. & S., Ltd.	Ord.	5/-	7/3
Modern Engineering Machine Tools, Ltd.	Ord.	5/-	11/-
Newall Engineering Co., Ltd.	Ord.	2/-	5/-
Newman Industries, Ltd.	Ord.	2/-	2/9
" "	6% Prf. Ord.	5/-	5/6
Noble & Lund, Ltd.	Ord.	2/-	4/9
Osborn (Samuel) & Co., Ltd.	Ord.	5/-	18/3 ex rights
" " "	5½% Cum. Prf.	£1	25/6
Pratt (F.) & Co., Ltd.	Ord.	5/-	19/4½xd
Scottish MachineTool Corporation, Ltd.	Ord.	4/-	4/9
Shardlow (Ambrose) & Co., Ltd.	Ord.	£1	35/-
Shaw (John) & Sons, Wolverhampton, Ltd.	Ord.	5/-	12/6
Sheffield Twist Drill& Steel Co., Ltd	Ord.	4/-	35/-
" " " "	5% Cum. Prf.	£1	15/-
Stedall & Co., Ltd.	Ord.	5/-	5/3
Tap & Die Corporation, Ltd.	Ord.	5/-	8/-
" " "	4½% Deb. 1961-1977	Stk.	82/-
Wadkin, Ltd.	Ord.	10/-	19/6
Ward (Thos. W.), Ltd.	Ord.	£1	73/1½
" "	5% Cum. 1st Prf.	£1	15/-
" "	5% Cum. 2nd Prf.	£1	24/3
Willson Lathes, Ltd.	Ord.	1/-	2/4½

The Middle Prices given in the list are in several cases nominal prices only and not actual dealing prices. Every effort is made to ensure accuracy, but no liability can be accepted for any error. * Sheffield price. † Birmingham price.